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AUTHOR Hays, Irene de la Bretonne
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ABSTRACT

The purpose of this study was to identify and explore values and views that might underlie an essential ethic for teaching science in the new millennium. With such an ethic, teachers may be better able to prepare young people to form and fully participate in communities that restore and sustain Earth. Reviewed in the literature for this study were changing philosophies and theories from early indigenous cultures to the present on the nature of nature, the value of nature, and the human relationship with nature. These philosophies and theories were found to influence values that today underlie the work scientists do and the ways young people are educated in science. In the study, two groups of participants--nature writers and scientists--revealed the essence and meaning of their relationship with nature. A two-stage, modified Delphi method was used for collecting data. Stage One comprised the first round of the Delphi and involved content analysis of writings by a select group of U.S. nature writers from the early 1800s to the present. In Stage Two, comprising three rounds of the modified Delphi, perspectives of nature writers were imbedded in questionnaires and presented for response to a select group of scientists connected with research and education at National Laboratories across the country. Finally, results from each participant group were brought together in a recursive process, one with the other, to determine findings. Strong Earth-care values, including receptivity, responsibility, interdependence, respect, cooperation, love, and care were found to be held in common by the nature writers and scientists in this study and could form the foundation for an essential ethic for teaching science. The strongest dissonance between nature writers and scientists was evident in emotional and spiritual elements in stories told of their experiences with nature. Contrary to what might have been expected from scientists based on theories of science and practices of science education represented in the literature, few scientists revealed negative, utilitarian, or dominionistic affiliations with nature. In contrast, no nature writers revealed such affiliations. Contains 210 references. (Author/WRM)

TOWARD AN ESSENTIAL ETHIC FOR TEACHING SCIENCE IN THE NEW MILLENNIUM

BY

IRENE DE LA BRETONNE HAYS

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Approvals:

Committee Chair	Date
Committee Member	Date
Committee Member	Date
Department Chair	Date
Dean	Date

ABSTRACT

TOWARD AN ESSENTIAL ETHIC FOR TEACHING SCIENCE

IN THE NEW MILLENNIUM

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TABLE OF CONTENTS

LIST OF TABLES

Page

Table

LIST OF FIGURES

Page

Figure

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CHAPTER 1

Introduction

> In the relations of humans with the animals, with the flowers, with the objects of creation, there is a whole great ethic scarcely seen as yet, but which will eventually break through into the light and be the corollary and the complement to human ethics.
>
> --Victor Hugo, 1943

Human perception is an uncanny thing: A way of seeing is also a way of not seeing. The lens through which we as human view the "more-than-human world" determines what we see (Abram, 1996). How important is it to understand the values and views that make up our knowledge of the nature of nature, the value of nature, and the human relationship with nature? That question is the focus of this study.

Statement of the Problem

Human response has proven inadequate to abate continued degradation and fragmentation of our ecological communities. Similar effects can be found in our social and civic communities, in our schools and families, and, some say, within the human psyche and soul. Many researchers believe these conditions are linked cyclically and are imploding, creating a downward spiral toward loss of vital species, including, inevitably, the human species (Etzioni, 1995; Fox, 1994; Gore, 1993; Hanley, 1997; Hawken, 1993; Merchant, 1996; Roszak, Gomes, & Kanner, 1955).

Individuals of strong will and good heart and institutions of benevolent power and magnanimous authority have sought to reverse the trend. Evolutionary and ecological processes inherent in Earth systems, including the human being as a system or as part of

the whole, naturally tend toward sustainability. Nevertheless, we have yet to regain that state of dynamic equilibrium where natural systems, human and nonhuman alike, flourish and prosper. We urgently need a return to wholeness, that "wildness" in which, said Henry David Thoreau (1937), is the "preservation of the world" (p. 672).

The application of science holds major promise for alleviating ecological distress, renewing life-sustaining processes, and thereby passing on a livable future on Earth to generations to follow (Gore, 1993; Lane, 1997). We look to our education system, particularly science education, to prepare young people for the task. Science education is now undergoing reform in its content and pedagogy; new standards, also called essential academic learnings, are being introduced. These efforts, though laudable, beg the deeper questions: What values must be instilled in young people so they are prepared to form and fully participate in communities that restore and sustain Earth? What essential ethic must underlie the new essential academic learnings?

At the root of our ecological crisis is a philosophical perspective that appears to be inadequate for now and for the new millennium. Historical literature tells us that modern science was founded on a perception held by early philosophers that mind and body were totally separate and that mind, "the diviner part" (Plato) of us, was imbued with spirit or soul. Body or matter, on the other hand, was considered to be wholly determinate through mathematical measures and scientific analyses. Thus, the natural world, the human body, and all beings other than human were subject to human use and dominance--exploitation at worst, stewardship at best. This narrow band of relationship denies the

innate affiliation between humans and the more-than-human world, including denial of feminine and spiritual dimensions (Abram, 1996; Diamond & Orenstein, 1990; Eisler; 1990; Fox, 1994; Kellert, 1996; Sheldrake, 1991; Swimme & Berry, 1992; Teilhard de Chardin, 1965; Wilson, 1984). Despite the advent of ecology and the "new" sciences of complexity which challenge earlier philosophical assumptions, an outdated world view continues to permeate science education.

Studies of science curricula, including textbooks and classroom practice, reveal that the "old" mechanistic world view continues to dominate (Gudmuundsdottir, 1990; Kesselheim, 1993). Furthermore, the widely perceived disparity between the "two cultures"--the disciplines of science and humanities--is reflected by students of science who have no use for humanities and students of humanities who cannot comprehend science (Snow, 1959; Tobias, 1990; Tobias & Abel, 1990). This evidence calls into question the goals, completeness, and potential efficacy of current science education reform which has as its overarching goal, science for all.

The public is ambivalent about supporting moral education and the teaching of values and often resists proposals that values be considered a part of education. Nevertheless, a renewed interest is emerging in schools to teach values and character. This interest arises from public demand growing from a broad-based concern for the ecological health of our communities and our environment and the moral health of our institutions, leaders, and children (Bates, 1995; Bennett, 1993; Cohen, 1995; Coles, 1995; Etzioni, 1995; Hillman, 1996; Lickona, 1991; Noddings, 1995).

Some believe that science education is values-free, as is the practice of science, and should remain so. However, a preponderance of historical and empirical evidence insists that neither education nor science is values-free, no matter the effort to make it so (Proper, Wideen, & Ivany, 1988; Ramsey, 1992). No attention to values leaves science education to the value norms embedded in the historical evolution of the scientific enterprise and reflected in past educational practices and policies. To consciously develop values for science education, we must go through philosophy (Bateson, 1991; Gough & Kessen, 1992). A new philosophical perspective will require, and will result in, the formation of new understandings of the nature of nature, the value of nature, and the human relationship with nature. An exploration of these understandings and the values that underlie them is the focus of this study.

Research Tradition and Design

The qualitative research tradition of this study is phenomenological as is the subject of the exploration itself which focuses on accounting for the intersubjectivity of human experience of phenomena in the natural world. An "associative empathy" between observer and observed in both cases naturally affects the findings (Husserl, 1931/1960). Romantic poet William Wordsworth (1798) acknowledged the intersubjectivity of perception in speaking of "all that we behold . . . of eye, and ear--both what they half create, and what perceive" (p. 99). And in the words of French philosopher Merleau-Ponty (1962): "All my knowledge of the world, even my scientific knowledge, is gained from my own particular point of view, or from some experience of

the world without which the symbols of science would be meaningless" (p. viii). Scientists, Nature Writers, the reader, the writer, and the more-than-human world all are participant-observers in this study.

Participant-Observers in this Study

To uncover values fundamental to an essential ethic for teaching science, I turned to a special class of participants--Nature Writers and scientists--who by virtue of their vocations or avocations are among those most intimate with the natural world. The Nature Writers are among those whose writing since the early 1800s has been widely read and influential in developing ecological consciousness and conscience (Finch & Elder, 1990; Worster, 1977). The scientists are among those nominated for their connection to research and education at U.S. National Laboratories across the country.

Data Collection

Through a two-stage modified Delphi method, both groups of participants revealed the essence and the meaning of their relationship with nature. The design and procedures brought forth the views and values of both participant groups in one continuous process. In Stage One, the perspectives of the Nature Writers were drawn from their writing and taken to the scientists in Stage Two, which included three rounds of questionnaires. Finally, the results from each group were brought together in a recursive process, one with the other, to reveal either dissonance, a disparity of views or values, or resonance, a concurrence of views or values.

Research Questions

Following are the research questions for this study:

1. What values and views are held by those most intimate with the natural world, among them Nature Writers and scientists?

    a. What values in relation to the natural world are revealed in the writings of the Nature Writers?

    b. How important do scientists believe these values are to their work and to the science education of young people?

    c. Is there a resonance and/or a dissonance of values between the Nature Writers and scientists?

    d. How do scientists experience the phenomenon of nature? What meaning do they give to their experience?

2. What values, themes, and perspectives emerge from the voices of Nature Writers and scientists--on the nature of nature, the value of nature, and the human relationship to nature?

Assumptions and Limitations

This study rests on several assumptions. One assumption is that the natural world, our habitat, is a legitimate and necessary study for all who live in it, not merely for the few who become scientists. Therefore, science education is a ready and appropriate pathway for stimulating reflection and instilling values needed to restore and sustain Earth. A second assumption is that there is value in listening to those who are not merely observers, but are immersed in a system, and are, therefore, intimately knowledgeable of the phenomena being studied. A third assumption is that science education has not listened well to those closest to the Earth, among them Nature Writers and scientists. A fourth assumption is that an essential ethic for teaching science, combined with essential

academic learnings, has the potential for developing leadership needed to restore and sustain Earth.

Although the Delphi method is well-suited to the elusive and subjective character of the topic as well as to the characteristics of the participants, it is nevertheless limited in that words on paper, despite careful composing, may connote more than one meaning. Even though a genuine meeting of minds is the intent of the several rounds of a Delphi questionnaire, participants lack opportunity for immediate verbal clarification. Care was taken in this study to reconcile disparities and discrepancies in participants' responses that might have resulted from differing interpretations of language.

Definitions

Definitions of the following terms are intended to help clarify the study's purpose:

Essential Ethic: An understanding of essential ethic derives from combining a purpose of essentialism--immutable principles, intrinsically right or wrong as defined by right reason, human nature, "God," or natural law--with an ethic, a body of principles of right and good conduct. An essential ethic for teaching and learning is also presented as an imperative corollary to essential academic learnings, a component of education reform.

Teaching science: In this study, science and science education refer to teaching and learning about the natural world and understanding scientific principles and processes wherever such teaching and learning may be found across the curriculum. It means more than the content of discrete academic disciplines and encompasses physical and life

sciences, earth and environmental sciences, computational sciences, mathematics, technology, and engineering.

New Millennium: Results of this study point toward the new millennium, indicating the kind of thinking and planning that extends to "seven generations" and beyond. Such thinking refers to the capacity of a system to endure and calls for action that leads to sustainability.

Organization

Answers to the research questions, along with the review of literature found in Chapter 2, inform the findings of this study. Chapters 3, 4, and 5 describe the research design, procedures, and analysis of data. Chapter 6 summarizes the meanings and implications of the findings and recommends areas of additional research.

CHAPTER 2

Review of the Literature

Introduction

The human relationship to nature has undergone dramatic changes from early indigenous cultures to the present. The changes have arisen from changing philosophies and theories of the nature of nature and the value of nature. Modern science, shaped at its inception and to the present day by these changing philosophies, has had a significant impact on the human relationship to the natural world. These changing philosophies and theories influence the values that today underlie the work scientists do and the ways young people are educated in science.

This chapter reviews philosophical perspectives and theories that have contributed to changing understandings of the nature of nature and the value of nature and their influence on today's science and science education. Three main sections make up this chapter. The first section traces a historical overview of changing perspectives on the nature of nature from antiquity to foundations of Western civilization, attributing changes to various philosophies and the philosophers behind them. The second section presents theories of the value of nature that account for modern science and its prevailing perceived relationship to the natural world and the consequent human relationship to nature. The third section describes research and expert opinion regarding the place of values in science and science education and the potential for an essential ethic for teaching science.

The Nature of Nature

Long before René Descartes and his followers bifurcated the universe into two mutually exclusive realms, mind (or spirit) and matter, human understanding of the nature of nature rested on a foundation of knowledge embedded in cultures of native peoples who carefully and systematically observed animals, plants, seasons, landscapes and places, and counted them sacred. Symbolic, mythic, and ritual artifacts reveal centuries of belief in a primal state of unity from which came all diversity and in which the sacred was immanent in the physical world.

An ethic of right relations with the land and the vast web of life permeated these cultures, based on a perceived kinship between the tribes of living, dead, and yet unborn. The kinship included the land, its geography, and all its inhabitants, both animate and inanimate nature. Theirs was a concrete knowledge in practice, yet connected to spirit powers and presences believed to animate the universe.

Reclaiming core teachings and practices of native traditions, ecofeminists and critics of deconstructive postmodernism describe native traditions that pre-existed the advent of modern science (Bigwood, 1993; Diamond & Ornstein, 1990; Eisler, 1990; Gaard, 1993; Spretnak, 1991). Dimensions of these ancient traditions and cultures were evident at least as far back as 6500 B.C. Worship of the Goddess predates that of a male deity in many cultures. At the heart of early Goddess cultures was honoring the personal body and the "Earthbody" (Spretnak, 1991, p. 133). Evidence exists that our Neolithic and probably even Paleolithic ancestors perceived nature as the embodiment of a fertile

female who was honored and revered. Ancient cultures of India and China developed traditions based on empirical knowledge of the universe (Capra, 1992). They studied the great wheel of the seasons as a model for human life--from birth through growth, maturity, decline, death, and rebirth. Refined models of consciousness grew from their perceptions of the changes and transformations evident in the natural world. They observed in the natural order ceaseless motion, continual flow and change, and a balance of opposites--Yin and Yang--neither having precedence over the other. Their mystical experiences were grounded in the natural elements of earth, water, fire, and air.

Human intimacy with all beings not human was central to Native American cultures. Shaman, or medicine people, were healers, not only of people but of the land. A "Great Mysterious" reigned over the family of humans and the rest of the earth community, including the stars and moon (Spretnak, 1991, p. 90). Neglect or abuse of the land resulted in loss of contact with the spirit world.

Spretnak (1991) presented a cross-cultural perspective of great wisdom traditions now marginalized by modern culture. Hers was not an encyclopedic presentation, but rather a representation of the core of each tradition as it once existed and as vestiges of it remain today. Her work urged us to reclaim a relationship with nature. She lamented that returning "home" was most often labeled unsophisticated and absurdly sentimental and sometimes pathologic by modern critics. Nevertheless, according to Spretnak (1991), nature knows us, our bodies know us, and await our return.

Pre-Socratic View of Nature

A radical break from these grounded traditions came from the pre-Socratic philosophers (roughly 600-400 B.C.) who, despite their grounding, combined complexity and abstraction with deep concrete knowledge of natural transforming elements. Though they introduced the power of reason to explain the workings of the universe, they nevertheless conveyed their thoughts in an oral-poetic mode of discourse and their attention was still turned toward the "sensuous terrain that surrounded them" (Abram, 1996, p. 108). The following are brief descriptions of reported words and thoughts of four pre-Socratic Greek philosophers--Heraclitus, Pythagoras, Empedocles, and Thales--who remained grounded in natural phenomena while pointing the way to the dawn of Western analytical science. Their thoughts survived in remnants of letters and poems and in references by later writers to books not now extant.

"Everything flows," said Heraclitus, who was a particularly important transitional figure among the pre-Socratics (Capra, 1996, p. 43). He spoke out against the dualism that was becoming apparent in Greek culture. Though he saw contrary forces in nature, he believed they were inseparable and formed a unity. He believed that all events in the universe took place according to a "Logos," a term he left undefined but which seemed to mean both the truth about things and the principles on which they functioned (Stokes, 1967). He thought the Logos would be accessible to humans if it were not for their folly. Logos was a kind of formula, a way of describing a unity of opposites. This unity of opposites supported Heraclitus' theory of flux, a theory that everything was in motion,

and therefore inaccessible to knowledge. He compared all things to a river, continuously changing. Attributed to him is the often quoted, "One cannot step twice into the same river," illustrating his doctrine of simultaneously converging and diverging opposites (Stokes, 1967, p. 479).

For Heraclitus, there was a Logos of the soul; therefore, souls fit into the cosmic flux. He saw the soul as both agent and interpreter of sensations. Its relation to the body was that of spider to web. In his image, the soul was firmly and proportionally joined to the body and rushed to any injured part of it. Heraclitus' grounding in nature was evident in his teachings and his tendency toward monotheism was observable, but not verifiable, in his reported writings.

Heraclitus was perhaps the first Greek speculative philosopher to raise the question of the validity of sense perception. He believed that facts were necessary but not sufficient for insight. He did not believe, however, that the senses actually deceived. He was reported to have said, "I prefer things of which there is sight, hearing, learning," and also that "lovers of wisdom must be good inquirers into many things" (Stokes, 1967, pp. 479-480).

Pythagoras was best known for the theory that "things are numbers" (Guthrie, 1967, p. 38). Pythagoras' interest in observable nature was not motivated by disinterested scientific curiosity. It was the basis of a way of life leading to salvation of the soul. He expounded strong mystical views including belief in the transmigration of souls which supported a profound distinction between body and soul or mind (Capra,

1982). At the center of his philosophy was the relation of humans to other forms of life and to the cosmos. Though he believed all things were composed of contraries, he saw that a kinship or sympathy was part of the essential unity of all life.

For Pythagoras, reason was needed to gain understanding of the observable universe. He was the first to call the world "kosmos," "from its inherent order" or harmonia (Guthrie, 1967, p. 38). By studying this order, he believed humans reproduced, in their own souls, a harmony. For him, this sense of harmony, applied specifically to music, meant any well-organized structure of parts fitted together in proper proportion. Its effect on music--this harmonia--seemed to have revealed to Pythagoras the harmony of the whole cosmic system.

Empedocles was a poet, prophet, and natural philosopher (Kahn, 1967). He is credited with originating the doctrine of the four elements. He "taught a materialistic theory of the psyche, according to which all thought and perception were dependent on bodily change" (Capra, 1982, p. 166). For him, the life cycle of the universe oscillated between unity and diversity. He continued to maintain a kind of Pythagorean dualism, believing the soul had a different nature than the body. He saw an invisible, incorporeal, nonanthropomorphic deity, characterized as a "Holy mind alone, darting through the whole cosmos with rapid thoughts" (Kahn, 1967, p. 498). While he believed that two opposing principles--love and hate--existed, he saw evidence of the universal power of love in the cosmos. Love triumphed over strife and represented the power of organic unity and creative combination.

Thales was the founder of the Ionian school of natural philosophy and was credited with specific discoveries in physics, metaphysics, astronomy, geometry, and engineering (Diamondopoulos, 1967). A visionary of his time, he asserted that the world originated in water and was sustained by water. He believed that water was the ultimate constituent of matter and that the earth floated on water and was perfectly understandable through the idea of water. Water was versatile, common, and powerful enough to account for every physical phenomenon.

In the natural world, Thales saw natural change everywhere and believed the world to be animated. For him, even apparently inanimate objects possessed psyche, the principle of self-motion. He saw nature as mysteriously animate and alive. The essence of this aliveness was to be found in the four fundamental elements--earth, air, fire, and water. Thales concluded, "All things are full of Gods" (Abram, 1996, p. 108).

The pre-Socratic philosophers represent a tradition that respected myth, a tradition fond of intuitions and one that did not concern itself with proofs. But they were also the founders of a new approach that attempted to comprehend the world through reason.

Socrates, Plato, and Aristotle asserted the doctrine of transcendent reason. Moving further away from the observed--the thing in itself--their reality was beyond the concrete. "There are two desires natural in man, one of food for the sake of the body, and one of wisdom for the sake of the diviner part of us," thus spoke Plato of the nature of nature. To him, humans were one part bodily passions, one part higher emotions or spiritual.

Plato's dialogues tended to support the view that the soul exists independently of the body and that the intelligible world is independent of the world perceived by the senses. True being is represented by the Idea in the mind. Plato seemed to support the notion that ignorance produced by the soul's union with the body resulted in moral evil. Consequently, Plato introduced the mind-body conflict that has existed without being reconciled fully throughout Western philosophy, religion, and science (Capra, 1982).

In love with the symbol and expression--the Logos--Aristotle's human-centered world view transcended the senses. Though he was much more a monist than his teacher, Plato, and departed from a radical dualism of mind and body, he held to the Platonic view of the soul as transcendent over physical senses. For him, substances differed because their nature or essence differed revealing an intrinsic duality. Nevertheless, he criticized Plato for completely separating Idea from things of the senses.

Aristotle fashioned a kind of hierarchy of beings with male soul, or mind, having precedence over female, and humans having transcendence over other beings. He tried to restore a continuity between the lower and the higher life by declaring that, at each level, matter is already potentially the form it is actually. He further asserted that the essence or animating principle of a thing determines its form and function, thus combining an empirical-based metaphysics with a rationalistic perspective.

At this early stage of the development of science, seeds were evident of what would become enduring themes in Western civilization--the question of the character of the elemental constituents of the physical universe and the question of the character of

ourselves. Are we and the universe wholly material and determinate, or are we and the universe animated, either by immortal souls or a vital force?

With Western philosophy, medieval and early modern, nature became so abstracted that it was no longer phenomenological. The Stoics believed in a spiritualistic monism, seeing the whole world as mind or reason. The monism of the Epicureans reduced everything to atoms. To them, all properties of things resulted from the structure of matter and everything had the same essence or nature. Euclid abstracted all the character and diversity of landscapes and places and reduced the world of appearance to essences.

Christian medieval philosophy leaned principally on Plato but after the 13th century moved more toward Aristotle, modifying some theories to bring them into harmony with Christ. Despite the claim that the "Word," or Logos, "was made flesh," the resulting Judeo-Christian ethic claimed that nature was created by God exclusively to serve human needs and endeavors (John 1:14). The Medieval Church, through the superstitions of Gnosticism, promoted the belief that the heavenly bodies were made of a different kind of "stuff" than mere earthly things. Mind was transcendent and, in the guise of spirit, was the locus of goodness. The material, physical, earth-based world was the opposite.

Radical dualism was revived by René Descartes, usually regarded as the founder of modern philosophy. He sharply divided reality between mind and matter and set out to build a whole new system of thought based on his vision of "the foundations of a

marvelous science" (Capra, 1982, p. 57). He sought to explain every fact in the material world solely by geometry and mechanics. To him, the material universe was a machine in which no spirit existed.

His vision gave him a firm belief in the certainty of scientific knowledge. This certainty was mathematical in its essential nature. In mathematics, the representation of natural phenomena became primary; the concrete reality, secondary. Thus was born Descartes' "Cognito, ergo sum"--"I think, therefore I am," an analytic approach to reasoning one's way through the universe, using deduction and intuition (Capra, 1982, p. 40). This analytic method is probably Descartes' greatest contribution to science and has been extremely useful in developing scientific theories and realizing complex technological projects, such as putting a human on the moon or improving transportation or energy systems on earth. On the other hand, overemphasizing analysis has fragmented thinking and academic disciplines. More than any other philosopher before or after him, Descartes' influence brought about the widespread attitude of reductionism in science--the belief that all aspects of complex phenomena can be understood by reducing them to their constituent parts. Descartes' method, along with Galileo's influence and Newton's mechanistic science, led Western thought to the conclusion that the "Book of Nature" could be read only through the predictive power of mathematics.

Descartes' successors, Spinoza and Leibnez, sought to restore a unity between mind and matter. Spinoza thought of them as but two attributes of the one substance, God. Leibnez pictured all reality as thought while distinguishing in a less radical way the

soul from the body. Immanuel Kant criticized Descartes' dualism but supported the division by claiming that there are somehow two worlds: one of phenomena and the other, the true reality, formed from a consciousness of moral duty. Although history of Western philosophy appears to show an alternation of dualism and monism, a Platonic, Cartesian, and Kantian dualism has endured.

Dualism was developed and has endured partly because religion in the form of the Catholic Church dominated the science of the sixteenth and seventeenth centuries. An example of its dominance was the house arrest of a gifted scientist--Galileo--for suggesting theories the Church refuted. The ideas of dualism and atomism reflected the need for science to free itself from control by the church for very practical reasons, one of which was that the population was expanding beyond the readily available food supply. More efficient trading practices and greater political freedom were demanded. Science could offer solutions to these practical problems. Placing science and the Church into radically different domains effectively freed science from the Church. In doing so, however, the nature of matter and therefore the nature of science was defined as the study of non-thinking bits of material having nothing to do with values. Thus, science became, almost by historical happenstance, juxtaposed to the spiritual.

Many later philosophers attempted to refute or to avoid dualism, with little success. Science remained largely abstracted to mathematics essences. In sociology, affected by modern science, forgetfulness of nature was almost complete. And the humanities became so anthropocentric that the natural world was near invisible. The

nature of nature was thus reduced to inert symbols fixed in place by humans--humans so transfixed by their own minds they became cut off from the Earthbody and their own.

A Second Look at the Nature of Nature

It took a long time and massive changes in human populations, population densities, and human access to powerful resources and technologies to openly reveal the dark side of Western science as we know it. Results of almost exclusive reliance on Western science as the highest form of knowing have been pointed out by many (Bateson, 1979, 1991; Capra, 1992, 1995; Snow, 1959; Worster, 1977). Even though the scientific method has advanced material progress, it has taken tolls on the environment, culture and community, and the individual. Important areas of knowledge and ways of knowing have been rejected when they differed from the particular culture and biases of science.

Gregory Bateson (1979) taught that a one-sided epistemology limits the ability to deal with most of today's major crises, including overpopulation and environmental impacts of technological progress. He said that our "values" are wrong and that pride in our scientific progress has bred a destructive arrogance. He believed also that evolutionary theory, mind-body problems, and epistemology are all one subject. He illustrated that belief by describing what he saw as the effect on human discourse of using Cartesian diagrams to describe reality. Although the use of these diagrams has been profitable, Bateson (1991) described their limiting impact on thinking:

> When you start arranging your words and explanations on that sort of a tautology, that set of basic notions about how things are related--you will of necessity end up with the sort of split between mind and body that

> Descartes ended up with. That split, you know has long been the battle ground of science, especially of biology, for a very long time. And the problem is how to get away from it. . . . You see the moment you go to the extreme materialistic end, which has these dimensions and quantities in it, and the nice curves and all the rest of it, the moment you specialize on that side, the thing bubbles up on the mental side with all sorts of mental-spiritual notions which you excluded from your materialism. You squeezed them out from one context and they bubbled up in another. The moment you do that, you're split wide open. . . . Now, it may be that there are total splits in the universe. I prefer to believe that it is rather one universe than two. . . . You see, a fellow in a speedboat thinks he is going at a "speed." He things he can measure the speed with a speedometer. But that's really not true. . . . The truth is that he's having fun. And the relationship of the fun to the speed is very obscure. Perhaps what he's having fun with is (his opinion about) the probability of disaster. Probabilities, you know, are of zero dimensions. I don't know the dimensions of "opinion." . . . You see, we've been pulling these analogies and metaphors out of physics and then trying to map human behavior, love, hate, beauty, ugliness onto these metaphors. (pp. 175-176)

Bateson thought that scientific description itself supports dualism, often limiting and distorting what we think we have come to know about a subject:

> In this Platonic universe, the analogues of dimensions are names and classes and logical types. We are dealing not with "real" dimensions but with descriptions of dimensions, and the big enlightenment comes when you suddenly realize that all this stuff is description. And when you realize that, then you realize that it's possible to be wrong in how you organize your descriptions, and it's possible to be wrong for this reason: the creatures we talk about--people, sea urchins, starfish, beetles, plants, cabbages, whatnot--all these creatures themselves contain description. The DNA are descriptive prescriptions, injunctions, for how to make a bird or a man or whatever. And these injunctions, therefore, themselves contain epistemology. They contain an implicit theory of the nature of description. You can never get away from theories of the nature of description whenever, wherever you have descriptions. All descriptions are based on theories of how to make descriptions. You cannot claim to have no epistemology. And every description is based upon, and contains implicitly, a theory of how to describe. The Cartesian coordinates contain a theory of how to describe, and for many purposes, I believe, it is an inappropriate and dangerous theory--one which in the end leads to various sorts of quantification of "things" which probably should be regarded as

> patterns, not quantities. It also leads to conceptual separation of mind and matter. You see, you can be wrong in describing the anatomy of a human being when you say he has five banana-like objects on the end of each limb, because, you see, he might not have "five fingers" on the end of each limb, but "four angles between fingers." The question is, what is there in the genetic injunctions, the prescriptive descriptions, for how to make a hand? Is there a number at all? "five," or "four," or whatever? Is there conceivably a rule of symmetry there? Is each limb itself primarily bilaterally symmetrical, like a feather? We have here an almost total gap in our genetic knowledge. (p. 177)

The first step to accounting for or remedying a dualistic perspective is to acknowledge that it exists. Applying this conclusion to ecological balance, Bateson thought that we have for too long accepted the premise that we need to fight for the survival of a particular individual or family line, or species or subspecies. Bateson (1991) said, "We have now achieved, I hope, empirical proof that premise won't do any longer; in fact, the unit of survival is organism in environment [emphasis in original], and not organism versus environment" (p. 171).

An important legacy of Bateson's many books and lectures is the assertion that the mind-body problem is soluble when we consider how we come to know a thing (epistemology) and the presuppositions that underlie a particular way of knowing--presuppositions about science or everyday life. He believed that "muddleheadedness is not necessary" and that we can come to know the interrelationships between consciousness, aesthetics, and the sacred by becoming conscious of the pattern that connects all living entities (Bateson, 1979, p. 209). (Note that the concept of metapatterns was borrowed by Tyler Volk (1995) who studied with Bateson. Volk developed the concept into an enlightening view of the functional, universal forms and

patterns that appear throughout the spectrum of reality. Studying these patterns represents a kind of epistemology for understanding connections in nature and the mind. Volk's treatment is both playful and intuitive as well as logical and explanatory.)

Further, Bateson (1979) asserted, in the form of a memorandum to the University of California Board of Regents on which he served, that the presuppositions or premises of thought upon which teaching was based at the time were "pragmatically and intellectually obsolete," particularly in relation to the following notions:

> a. The Cartesian dualism separating "mind" and "matter."
>
> b. The strange physicalism of the metaphors which we use to describe and explain mental phenomena--"power," "tension," "energy," "social forces," etc.
>
> c. Our anti-aesthetic assumption, borrowed from the emphasis which Bacon, Locke, and Newton long ago gave to the physical sciences, viz. that all phenomena (including the mental) can and shall be studied and evaluated in quantitative terms. (p. 217)

He challenged faculty and students to a wider perspective which was about perspectives, ways of seeing and knowing, that could bring synchrony or harmony between rigor and imagination.

Bateson did not believe that the scientific method or science itself was ever value-free. "Epistemology is always and inevitably personal," said Bateson (1979), "The point of the probe is always in the heart of the explorer" (pp. 87-88). When asked for his answer to the question of the nature of knowing, he said, "I surrender to the belief that my knowing is a small part of a wider integrated knowing that knits the entire biosphere or creation" (Bateson, 1979, p. 88).

C. P. Snow (1959), renowned British scientist, statesman, and writer, was also concerned about the need for "knitting" together disparate dimensions. He delivered a lecture in 1959 which provoked an enduring, often intense, controversy ongoing today. In what has come to be known as the "Two Cultures" lecture, Snow (1959) recognized a split in society between science and humanities:

> I believe the intellectual life of the whole of Western society is increasingly being split into two polar groups. . . . Between the two a gulf of mutual incomprehension--sometimes (particularly among the young) hostility and dislike, but most of all lack of understanding. They have a curious distorted image of each other. Their attitudes are so different that, even on the level of emotion, they can't find much common ground. . . . This polarisation is sheer loss to us all. (pp. 3-4)

Snow described each group as self-impoverished and, as with the tone-deaf, each group did not know what it was missing. Nonscientists dismissed scientists as ignorant specialists, while ignoring their own ignorance and specialization. He recalled his response to such discussions:

> Once or twice I have been provoked and have asked the company how many of them could describe the Second Law of Thermodynamics. The response was cold: it was also negative. Yet I was asking something which is about the scientific equivalent of: "Have you read a work of Shakespeare's?" (Snow, 1959, pp. 14-15)

Snow saw this split as disastrous, perhaps destructive:

> It is dangerous to have two cultures which can't or don't communicate. In a time when science is determining much of our destiny, that is, whether we live or die, it is dangerous in the most practical terms. Scientists can give bad advice and decision makers can't know whether it is good or bad. On the other hand, scientists in a divided culture provide a knowledge of some potentialities which is theirs alone. All this makes the political process more complex and some ways more dangerous than we should be prepared to tolerate for long. (Snow, 1959, p. 98)

Snow sought to bridge, to connect, the two cultures and mediate the polar split. He envisioned a third culture which would soften the communications difficulties and would be on speaking terms with the sciences and the humanities.

While the "Two Cultures" controversy may have been foreshadowed in early Greek philosophy, it surely revealed itself in the 17th century scientific revolution when science began to enjoy a special cultural authority. The fissure between the two types of knowledge and two ways of knowing opened further during the Romantic period at the end of the eighteenth and beginning of the nineteenth centuries. Some scholars began to contrast the creative or emotional energy released by poetry with that of a mechanistic human existence evident in the calculation and measurement of science. In education, champions of science literacy struggled to gain a place in the curriculum. Such struggles in education continue unresolved today, equally present in humanities and science.

The two-cultures problem continues to be discussed and decried: Neal Lane, director of the National Science Foundation, called for society to understand and appreciate the tremendous contributions science has made to our collective well-being and the role scientists play in "securing our future and solving society's problems" (Lane, 1997, p. B7).

Paradoxically, the scientific method has become a tool of wholeness in its own self examination. Quantum physics and chaos and systems theories have opened up understanding of a world fundamentally connected in some mysterious way. Richard Simonelli (1994), Native American science writer and leader, referred to John Bell, who

in 1964, proposed an experiment to test the nature of reality to resolve a debate among the leading physicists of the century, Niels Bohr and Albert Einstein. The result was Bell's Theorem which validated the quantum wholeness or connectedness hypothesis.

Simonelli reminded us that there are ways other than Western science to discover the inherent connectedness of the universe. He said, "This is the subject of some non-Western ways of knowing, as well as some parts of our own humanistic. artistic, and mystic traditions. Both Buddhist and Native American world views are about this holism" (Simonelli, 1994, p. 8). Thus, he linked a scientific rational way of knowing to ways of knowing that encompass other dimensions of human physical, emotional, and spiritual qualities, in addition to intellectual or mental--a true bridging of the cultures and communities, and, Simonelli believed, a path to healing people and the environment.

As Thomas Kuhn (1962) described it, a paradigm shift in science, notably physics, occurred at the beginning of the 20th century signaling a larger cultural transformation and a change in the human relationship with the natural world. The writings of Fritjof Capra communicate powerfully the dimensions of that shifting "constellation of achievements--concepts, values, techniques, etc.--shared by a scientific community and used by that community to define legitimate problems and solutions" (Kuhn, 1962, p. 1).

In a succession of books, including the Tao of Physics (1975), The Turning Point (1982), and The Web of Life (1996), Fritjof Capra described the tremendous fundamental change in thoughts, perceptions, and values that has led to a new vision of reality, a

systems view and beyond. He described the historical development and profound influence of Cartesian-Newtonian thought on biology, medicine, psychology, and economics, and also on our well-being as individuals and as a planet. In the Tao of Physics, he connected his work as a physicist with what he saw as a spiritual revolution and a revolutionary trend throughout society. The conceptual change in modern physics, at odds with the old social and economic structures, reflects the harmonious interrelatedness Capra and others now observe in nature. In The Turning Point, Capra described the new paradigm including a systems view of life, mind, consciousness, and evolution. He noted an emerging integration of Western and Eastern approaches in psychology and medicine, and new economic, ecological, and spiritual perspectives, including an awakening of the feminine. The Web of Life, also by Capra, offered an exciting synthesis integrating the so-called "new" sciences into a new deep ecology paradigm. This perception of reality has profound implications for science, philosophy, the environment, education--and almost every aspect of modern every day life. Capra's work offers a promising possibility of overcoming the Cartesian metaphor.

Within science itself, the paradigm shift at its deepest level has revealed that the most fundamental description of reality can be found not in physics but in the life sciences. Emerging new conceptions of the web of life, such as deep ecology and ecopsychology, encompass the whole system and all life processes, including the many dimensions of human cognition, emotion, psychology, and spirituality.

Worster (1977) investigated ecology's past, tracing the origins of the concept, the thinkers who shaped it, and the development of ecology since the 18th century. In his view, ecology, once considered a subversive subject, and which may still be for some, effectively called into question the bias against nature found in Western philosophy. Worster (1977) reviewed the work of early Nature Writers such as Henry David Thoreau, Rachel Carson, and Aldo Leopold whose approach to nature was ecological and whose writing has been a source of inspiration and guidance for the "subversive activism" of the recent ecology movement (p. 58). Roszak et al. (1955) writing of ecopsychology, and Abram (1996) writing of the fluid, participatory nature of perception and the reciprocity between our senses and the sensuous earth, have each provided perspectives that deepen our understanding of the significance of this paradigm shift described by Capra.

The Value of Nature

What is the value of nature? What good is it anyway? Must it have instrumental value to have a claim to existence? Does it have intrinsic value? Can it have value without a valuer? As part of nature, what good are we? Does my total value exceed my instrumental value? These questions and others have been asked and continue to be asked by philosophers, ethicists, environmentalists, among many others concerned about the human relationship with the natural world.

Theories of the Value of Nature

Economic terms have been applied to the value of nature. Seventy-eight cents is an economic measure summing up the value of constituent parts of a human. Thirty-three

trillion dollars a year is the sum researchers found for the benefits produced by the planet's air, water, soil, plants, and animals (Costanza, 1997). But economic terms alone leave fundamental questions unanswered. Ways to consider the question of the value of nature and various value schemes or heuristics have been proposed. What follows are descriptions of a number of representative perspectives on the value of nature.

J. Baird Callicott (1995) offered two proofs for the existence of intrinsic value in nature: a phenomenological proof and a teleological proof. The phenomenological proof rests on the consciousness we have as humans that we have intrinsic value even if we prove to be good for nothing. We sense this introspectively and irrefutably when asked, "What good are you?" The teleological proof derives from the fact that things of instrumental value exist for humans or have been created by humans. Referring to Aristotle's ethic that the existence of means values implies the existence of ends, Callicott concluded that humans, or the ends-in-themselves, have intrinsic value. But can we then attribute this same intrinsic value to nature? Callicott continued a line of reasoning that leads to what he calls a modern theory of the intrinsic value of nature. This theory rests on consideration of the properties of things-in-themselves from a Cartesian perspective, including Kant's distinctions between objective and subjective values. Considered also are Schweitzer's reverence for all beings having a will to live and the views of modern philosopher-ethicists Paul Taylor and Holmes Rolston III, whose sense of "inherent worth" and "systemic value," respectively, may be a prelude to

a postmodern account of value in nature. Callicott asserted that the new perspectives loosen the grip the Cartesian perspective has on the Western mind.

In search of an ethic for the human relating to the environment, Holmes Rolston III (1988) described his theory of values in the natural world, first describing nature's value to humans and the incumbent duties owed to animals, organic life, endangered species, and ecosystems. Values carried by nature to humans include life-support, economic, recreational, scientific, aesthetic, genetic-diversity, historical, cultural-symbolic, character-building, diversity-unity, stability and spontaneity, dialectical, life, and religious. Rolston further made a distinction between nature as a resource (an instrumental value) and nature as a source, an originary essence generating its own value. He concluded that instrumental value is not secondary when it is found throughout the system making everything an instrumental resource for others. According to Rolston, both instrumental and intrinsic values are distributed throughout the ecosystem, though not homogeneously but rather in a kind of proportional sense with non-biotic things (rivers, rocks, mountains) having minimal intrinsic value and humans having maximal intrinsic value. The most intrinsically valuable of all is the entire projective system or universe, from which even humans are projected values.

Rolston proposed that we can deduce the intrinsic value of nature by being convinced that all living things are self-valuing, which is functionally equivalent to objective intrinsic value. Rolston argued persuasively that intrinsic value in nature does not necessarily depend on a conscious subject and certainly not on a human subject. He

did so by showing, for example, that adaptations and survival and reproductive strategies of plants and other organisms that lack consciousness are of value to themselves, ergo, their instrumental value confers upon them intrinsic value (Callicott's teleological proof).

E. O. Wilson (1984), noted Harvard professor of science, proposed that humans have an innate tendency to focus on life and lifelike processes. This tendency he called "biophilia."

> To explore and affiliate with life is a deep and complicated process in mental development. To an extent still undervalued in philosophy and religion, our existence depends on this propensity, our spirit is woven from it, hope rises on its currents. (Wilson, 1984, p. 1)

He illustrated biophilia by describing our affinity and affiliation with super-organisms; development of species through geologic time; the art-like intuition and imagery of science (synthesis as well as analysis); humans (scientists and humanists alike) as the poetic species; and archetypes of nature buried deep in human consciousness, including our sense of the "right place" to live. Wilson (1984) lamented the growing human alienation from nature and, pointing to an environmental ethic based on biophilia, asked, "Is it possible that humanity will love life enough to save it" (p. 145).

A number of books have reflected on Wilson's Biophilia including a collection of articles in Biophilia Hypothesis, written by distinguished multidisciplinary scholars who met in 1992 to explore and debate elements of Wilson's compelling and provocative concept (Kellert & Wilson, 1993). The articles examined the theoretical and empirical evidence in support of the biophilia hypothesis. Explored is whether biophilia is inherent, part of our evolutionary heritage, associated with human competitive advantage and

genetic fitness, likely to increase the possibility for achieving individual meaning and personal fulfillment, and the basis of a human ethic of care and conservation. Themes include the role of nature in human cognitive and mental development, the biological basis for diverse values of nature, the evolutionary significance of the human aesthetic response to varying landscapes and species, the socio-biological importance of human altruism and helping behavior, and the role of nature in human emotional bonding and physical healing, among others. A central element of the book's overarching theme is the belief that the natural environment is critical to human meaning and fulfillment at the individual and societal level.

In the context of biophilia, Stephen Kellert (1996) developed a typology of basic values of living diversity that he described as integral to what it means to be fully human. He researched over many years what value humans place on living diversity emotionally, intellectually, and materially and found nine basic values. He examined how these values are modified by human demography, activity, relationships to varying species, and culture. From his findings, he concluded that if we are to achieve lives rich in meaning and value, we must recognize our profound dependence on living diversity. He concluded with educational and ethical concerns:

> Biodiversity education should seek to inform people, emotionally and intellectually, about the role of the living environment in their lives. . . . Biodiversity education must dispel this deep disconnection from the natural world. In its place it must instill the feeling, knowledge, and belief of how much human sustenance and spiritual enrichment depend on maintaining a rich variety of relationships to nature and living diversity. (Kellert, 1996, p. 211)

Kellert (1996) proposed an ethical challenge to develop a deep commitment to an ethic of care, concern, and compassion for all of life:

> Modern society continues in more silent and less obvious ways to destroy a substantial fraction of life on earth--perhaps to a greater degree than at any time in human history. Moreover, the average person remains but dimly aware of the scale of this impact...Thousands of singularly distinctive species, each a unique expression of millions of years of adaptational travail, oblige us to devote whatever wisdom and ethics we can to the task of slowing and then reversing this tide of ultimately self-defeating destruction. We need to alter what, in our collective insanity, we have come to regard as normal. (p. 214)

In a second book, Kellert (1997) argued that the full expression of biophilia is integral to our overall health and, therefore, concluded that the continued degradation of the environment may have far more serious consequence than many people realize. Our species evolved the values of nature because they enhance our capacity to survive and prosper. This natural, inborn tendency to value nature may wither without learning, experience, and support from the larger social context.

Reed and Slaymaker (1992) explored perspectives on ethics and sustainability within the context of a continuum of human relationship to nature from biocentrism (deep ecology) at one end of the spectrum to anthropocentrism (human-centered) at the other. They rejected biocentrism because the relation of humans to nature is more than a biological question, it is also a moral question. Deep ecology, they argued, can lead to morally reprehensible choices. They rejected anthropocentrism because it disassociates human beings from natural processes and tends to deny any moral obligation we may have for ecological "others." Unlimited faith in human ingenuity and technology often

characterizes the human-centered view of nature. Most profoundly, they concluded that both views tend to underestimate the subtle link between humans and the rest of the natural world. They proposed a middle perspective which recognizes human continuity with the natural world, but also its distinctness and independence. They pointed to views of ecological feminists and others, such as Gilligan (1982), who expressed self-in-relationship and represented an ethic of care, respect, and responsibility necessary for sustainability. Finally, they proposed that environmental ethics is a scale-dependent problem set with different expressions of ethics associated with each of the following scales: planetary; global; regional; and local.

A detailed account of the new and emerging field of ecopsychology is provided in a collection of over two dozen essays by distinguished scholars who attempted to redefine mental health within an ecological frame (Roszak et al., 1955). A number of common features unite the perspectives of ecologists, therapists, environmental philosophers, and environmental activists in ecopsychology. They examined the emotional bonds between humans and nature and within the larger context of cosmic patterns and concluded that the split between the ego and the natural world is an illusion. James Hillman, among others who wrote chapters in this book, asserted that the mental health of individuals is directly related to the environmental ills that confront us. Roszak decried the shocking and shaming strategies used by environmentalists to win over the minds of a psychologically fragile public. He called for a strategy that relies on the innate human

capacity for affiliating with the natural world, referencing once again E. O. Wilson's biophilia concept.

David Abram (1996) grounded ecology in the philosophy of the phenomenological perspectives of Edmund Husserl and Maurice Merleau-Ponty. This perspective leads us to understand the difference between the experienced world, or worlds, of indigenous cultures and the world of our modern civilization. By this, Abram attempted, as others have, to counter the long-standing dualism of mind and matter which has led to a split between our bodies and our spirits or souls. Abram wrote of returning to one's senses, which involves valuing literally and sensually our embodied senses--the tastes, sounds, touches, sights that surround us. He proposed that the new environmental ethic may come into being through a renewed attentiveness to the sensorial empathy with the living land that sustains, as was experienced by indigenous cultures. His thesis is that Western culture has neglected the sensuous in favor of writing nature down in algorithms that have only arbitrary connections with the beings they evoke. The very abstraction of this mathematical language leads to indifference toward the sensuous world and its meaning, according to Abram. Returning to our senses has serious ethical and political implications calling for a lived-out truth of involvement with nature which will help us make sense of what Abram calls the more-than-human world.

Anthony Weston (1994), who was David Abram's teacher, used Abram's term, the more-than-human, when he spoke of human embeddedness in the natural world, including human relationship with other animals and with the land. Weston argued that

contemporary environmental ethics is profoundly shaped by the very anthropocentrism that it tries to transcend. To counter this propensity, he called for a rethinking of environmental ethics keeping in mind the ecological evolution of ethical ideas, namely that they must be grounded in sensory experience with nature. Weston told his story of environmental practices with almost an absence of academic environmental philosophy. His writing reflects his theme: a return to the senses. Describing the human relation to the Earth, Weston (1994) used the words of Martin Buber: "Inscrutably involved, we live in the currents of universal reciprocity" (p. v).

Other concerned environmentalists have presented views similar to those of Weston and Abram. Don Marietta Jr. (1994), reminded us that "an ethic, with its owner, is lived as biography, a story line on location in historical time and geographical space" (p. xi). Al Gore (1993), insisted that we are part of the Earth. He said that a kind of "disconnection" underlies the environmental crisis:

> The cleavage in the modern world between mind and body, man and nature, has created a new kind of addiction: I believe that our civilization is, in effect, addicted to the consumption of the Earth itself. This addictive relationship distracts us from the pain of what we have lost: a direct experience of our connection to the vividness, vibrancy, and aliveness of the rest of the natural world. The froth and frenzy of industrialized civilization mask our deep loneliness for that communion with the world that can lift our spirits and fill our senses with the richness and immediacy of life itself. (Gore, 1993, pp. 220-221)

Although Gore (1993) spoke of the "vividness, vibrancy, and aliveness of the rest of the natural world," almost no evidence of that direct experience is found in all of Gore's book (p. 220). According to Weston (1994), whose views were described earlier, Gore spoke

from a human, urban, economic, and political perspective, with all problems discussed chiefly in terms of economic justice to humans, rather than from the more-than-human perspective proposed by Abram, noted earlier.

Feminine Values in Nature

In the mid-1970s, ecofeminism began emerging alongside feminism and environmentalism. For nearly three decades, literature of the ecofeminist perspective has been accumulating in journals and other texts. Generally, ecofeminist literature advances feminine values while seeking to strengthen the bonds between women and nature. A central position of ecofeminism is that women and nature have suffered parallel oppressions and that the struggles to advance feminine values and the value of nature are mutually beneficial.

Three themes dominate ecofeminist literature: 1) a political and historical theme that says domination is based on more than money and class--it is also based on gender, for women are a universally dominated class; 2) a religious theme honoring the Goddess and honoring nature itself as the source of the female divine in the form of Gaia; and 3) an environmentalist theme which grew from the desire of women policy makers and leaders to progress beyond the career-ladder blocks instituted by male-dominated environmentalism and become full-share partners in saving the planet.

Although much of ecofeminism does not fall exclusively into one of the three thematic categories described, the literature can be described from the thematic perspectives. Carolyn Merchant (1995), in her book EarthCare: Women and the

Environment, presents a perspective that calls for a partnership ethic where women and men are equals giving each other space, time and care, and humans are equal partners with nonhuman nature, allowing it to reproduce, evolve, and respond to human actions. Merchant's ecofeminism called for responsible care of the environment and allowed for the possibility of a personal or intimate relationship with nature. She avoided attributing gender to nature as in a nurturing mother or a goddess. Riane Eisler (1990) also reclaimed a partnership of women, men, and nature grounded in spirituality and ancient traditions of worshipping the Goddess of nature, a weaving together of two ecofeminist themes.

Carol Bigwood (1993), in her book Earth Muse: Feminism, Nature and Art, traced the historical evolution of women's place and consciousness as a dominated class and linked dishonor and disrespect of the female body with repression and degradation of nature. She shared her vision of a caring place where differences of gender, culture, human, and nonhuman could be openly encountered. This "world-earth-home" would be an environmental ethic of place, returning to the roots of ethics in ethos, a primordial bond of people with their natural, social and historical existence (Bigwood, 1993, p. 49).

Greta Gaard (1993), in her book Ecofeminism: Women, Animals, and Nature, intended to provide a theoretical bridge for women working in the various related movements of environmentalism, animal liberation, and feminism. Notably, her writing examined an area of debate in ecofeminism that criticized ecofeminists' use of Native American cultures when convenient for building theory. Nevertheless, Gaard asserted

that ecofeminism and environmentalism as well need to address such traditionally Native American concepts as the place of animals, the feminization of nature as "Mother Earth," and the movement to reclaim the goddess. Her premise is that ecofeminism has been articulated primarily from a White, feminist viewpoint and has much to learn from Native Americans who have no need for ecofeminism because their culture provides them understandings of the interdependence and interconnectedness of humans and nature. Ecofeminists can gain significant understandings from Native Americans in regard to killing animals and the meaning of "Mother Earth." For Native Americans, killing animals for food was the act of accepting the offer an animal makes to sustain human life. A Native American concept of Mother Earth does not have the same meaning as it does in Eurocentric Western culture; in fact, the Western conception of "mother" as endlessly giving may serve to "perpetuate the very notion ecofeminism seeks to eradicate" (Gaard, 1993, p. 302).

Irene Diamond and Gloria Feman Orenstein (1990), in a literary anthology, brought together a collection of writings on ecofeminism which represents all themes described earlier in this section. Diamond and Orenstein framed their collection in three important philosophical strains adopted by those who defend the Earth against abuse. The first gave the whole Earth intrinsic value with no part of it superior to any other part. The second philosophical strain emphasized that because human life depends on the Earth, humans must care for the Earth for their survival and well-being. The third called for understanding and care of the Earth because it has intrinsic value and because humans

depend on the Earth. Among the writers included are Brian Swimme whose story of the origin of the cosmos inspires a spiritual ethos; and Starhawk who described the mystery of an earth-based spirituality. Included are two writers, Marti Kheel and Michael Zimmerman, who reflected on the identity, difference, and dialogue between ecofeminism and deep ecology; and Gloria Orenstein, who described artists as healers of the earth and culture.

An intriguing perspective was offered by Linda Jean Shepherd (1993), who proposed that feminine principles are alive and well, though veiled, in modern science, and are infusing science with values such as feeling and love, receptivity, subjectivity, multiplicity, nurturing, cooperation, intuition, relatedness and social responsibility. Transcending Western notions of masculine and feminine, the practices of scientists and science itself reveal qualities that traditionally have been assigned to women rather than men. Drawn from deep Jungian understandings, Shepherd called for a recognition of feeling and intuition as complements to thinking and sensation in science. In science, she saw feminine principles in areas such as quantum physics and chaos science, changing the image of matter and the mechanical world view. Individuals coming together who hold feminine values can achieve a critical threshold which stimulates science institutions to reorganize themselves, as chaos science teaches. Shepherd (1993) stated,

> the Feminine in each of us--the part of us that sees life in context, the interconnectedness of everything, and the consequences of our actions on future generations--can help heal the wounds of our planet. (p. 1)

A contrary view was presented by Margaret Wertheim (1995) who declared, in her book Pythagoras' Trousers, that our modern science, particularly physics, has been stripped of feminine qualities by a masculine dominance that reflects the religious origins of science. Science has been so intimately intertwined with the institution of Christianity that women's battles to break into science parallel battles fought to break into the clergy. Wertheim described a continuing religious undercurrent that "worships" mathematical scientists as "high priests" and, thus, accounts for the under-representation of women and feminine values in science.

The literature of ecofeminism offers much to an understanding of the value of nature. It is an evolving movement and area of criticism. Perhaps its greatest contribution is that it calls attention to the feminine qualities inherent in nature and the potential for synergy among the interests of liberating both women and nature from abuse.

Spiritual Value of Nature

A number of the theories of the value of nature described in the previous sections include a moral or spiritual component or value (Kellert, 1996, 1996; Kellert & Wilson, 1993; Wilson, 1984; Worster, 1977). Some theorists linked the natural ecological crisis with a crisis of the human spirit (Gore, 1993; Roszak et al., 1955). Others, not previously described, focused first on the spiritual value of the human relationship to nature (Fox, 1984; Sheldrake, 1991; Swimme, 1984; Swimme & Berry, 1992; Teilhard de Chardin, 1959). The spirituality they described is based on the concept that human beings are part

of a larger, more encompassing reality. This connection is at the core of the world's great religions. But the mind-body dualism of science effectively separated the mind or spirit from the physical world and, therefore, from the practice of science. The following perspectives represent a return of science to a spiritual sense of being continuous with the natural world.

The scientific vision of Teilhard de Chardin (1959), naturalist, mystic, and metaphysicist, was a truly spiritual and mystical one. His vision of matter included a fundamental plurality, unity, and energy which, as he saw it, were all constituent parts of a universal wholeness. He believed that the struggle between materialists and those who experienced a spiritual connection with nature was a struggle between two schools of thought unable to find common ground. He believed strongly that the two points of view would be brought into a union in which the external and the internal aspect of the world would be taken into account. "Co-extensive to their Without, there is a Within to things," he said (Teilhard de Chardin, 1959, p. 56). The "Within" he described as the spiritual energy, ignored by modern science in its concern for material energy, but nevertheless evident and familiar to us all. To reconcile this fundamental dualism, Teilhard de Chardin proposed a coherent world view integrating scientific insights, mystical experiences, and theological doctrines. His thinking came close to that of complexity theory and Capra's web of life, but extended to a systems concept of God as the source of all being and of the universal dynamics of self-organization. Before the introduction of the new systems approach to the study of living organisms, Teilhard de Chardin's

scientific ideas were largely ignored, disdained, and sometimes attacked. Now they appear in a new light.

Brian Swimme (1984) and Thomas Berry (1992) conceived a new story of the universe, uniting science and the humanities. They described an ongoing intelligent and creative drama of evolutionary processes, including the genius of human emergence and development. They proposed a Cosmogenic Principle to supersede what has been seen as the ultimate principle--the second law of Thermodynamics. This new first principle they described as the order-generating powers of the universe, latent everywhere from the birth and development of galaxies to the self-ordering dynamics of a tropical forest. Awakening to the universe story involves listening to the natural world attuned to more than mechanistic science perceptions. Listening well has inspired serious ecology movements that exist today throughout the human community. For Swimme and Berry, the Cosmos draws humans into spiritual communion with nature for the "inner form of the mountains and the numinous quality of the sky have activated these depths in the human" (Swimme & Berry, 1992, p. 41).

Scientist Rupert Sheldrake (1991) described our fate within a Cartesian model of the world:

> Souls were withdrawn from the whole of the natural world. All nature was inanimate, soul-less, rather than alive. The soul was also withdrawn from the human body which became a mechanical automaton, leaving only the rational soul, the conscious mind in a small region of the brain. (p. 49)

Sheldrake traced the cultural origins and historical development of a mechanistic view of nature and the progress of science to transcend that world view. Sheldrake envisioned a

living, developing universe--a synthesis of traditional wisdom, intuitive experience, and scientific insight. Re-establishing our conscious sense of connection with living nature, according to Sheldrake (1991), is no less than a spiritual transformation, a "greening of science and God" (p. 182). Humans who choose the theory of a living God together with living nature, rather than alternative views of the human relationship to nature, must have a high "mystery-tolerance threshold" and be "consciously open to the mystery of divine consciousness, grace, and love" (Sheldrake, 1991, p. 203).

"At bottom," said radical philosopher and priest Matthew Fox (1984), speaking of the environmental crisis, "the issue is one of spirituality" (p. 9). The way to save the planet, according to Fox, is to put our own house in order first. The inner or spiritual work must precede the outer work. The inner environment of the human psyche, heart, mind, and soul must be balanced before the human can effectively attend to the outer work, the outer environment, or sustainability of the planet.

A return to nature for its spiritual value, but also as a value in and of itself, was promoted by a group of naturalists and scientists whose writing was at first uncategorizable within existing genres of literature. A description of that writing follows.

Advocates for the Value of Nature

More than any other single body of literature, the Nature Writing tradition represents a return to an intimate relationship between humans and the natural world. Because the field of Nature Writing literature is vast and crosses continents and centuries, no attempt will be made in this document to provide a comprehensive or detailed

description of the many dozens of Nature Writers and their writing. Rather, this section of the literature review will provide an overview of the meaning and the development of the Nature Writing tradition in this country with reference to contributions of selected writers who are among those writers later appearing as research "participants" in the methodology chapter of this document.

In the United States, the Nature Writing tradition began in the early 1800s and developed over nearly two centuries from early descriptions of nature apart from humans to today's writings that reflect the deepest integration of humans within the natural world. For the most part, the tradition of Nature Writing emerged from self-led naturalists, amateurs in out-of-the-way places. Through the naturalist tradition, people began falling back in love with the natural world. The Nature Writers recorded and continue to record this love relation.

The recovery of this ancient tradition, rooted in indigenous cultures, came not through religion, philosophy, or science, but rather through a set of paradoxes or polarities involving all three. In the late 18th and early 19th centuries in the United States, two streams of thought collided--romanticism and science. Simultaneously, two streams of historical conditions were paradoxically juxtaposed--vast wilderness and rapid settlement and industrialization. These two sets of polarities came together--a paradoxical synthesis--to form the Nature Writing tradition.

Romanticism emerged as a reaction to the industrial revolution, first in Germany, then France and England, and finally in the United States. English Nature Writers such

as William Wordsworth greatly influenced writers in the United States. In opposing the machines of the industrial era, the Romantics imbued nature--the organic--with character, spirit, and voice. These opposing forces were to the Romantics a question of life against death.

Transcendentalists, our early Nature Writers, believed that through contemplation of dynamic Nature we could access true essence, a spirit transcending ourselves. Under the influence of Romanticism and Transcendentalism, the old dualism disappeared and natural wilderness was no longer thought of as demonic. America was thought of as the garden of the world--the Garden of Eden--and the native peoples as the people of God. By embracing the wilderness, humans were thought to gain access to the primordial and originary ground of experience.

Transcendentalism and the Nature Writing tradition was birthed in the United States by Henry David Thoreau (b.1817-d.1862), Ralph Waldo Emerson (b.1803-d.1892) and a group of young counter-culture "gentlemen" scientists or naturalists as a response to theological speculation, an outcry against a Puritan-Calvinist heritage. Thoreau contributed careful, thorough descriptions of landscape and the turning of the seasons first as things-in-themselves, then as phenomenological representatives of the Divine--a neo-Platonic perspective. Traditional religion helped promote the argument that the world is the work of God's hand. This view was truly a fusion of head and heart, intuition and reason. Nature was the link, the grand synthesizer.

John Burroughs (b.1837-d.1921) departed from Thoreau's perspective by describing nature as it exists, seeking no "sermons" behind his observations of nature. With senses sharpened by knowledge of Darwin's scientific perspectives and influenced by the writing of Walt Whitman (b.1819-d.1842), Burroughs saw Nature as dynamic and transformational. Burroughs, as other Nature Writers, acknowledged the mystery of the spirit at the source of all matter. His work foreshadowed ecological perspectives to come, particularly the conservation of diminishing resources.

Close observation of nature by people of science was compatible with the naturalists' approach. But Romanticism infused even science with a spiritual dimension. Further support for this view was offered by Darwin, who revealed that everything is unfolding in the evolution and dynamism of a grand cosmic process. According to the Romantics, the process also had purpose, perhaps Divine.

A conservation theme emerged in Nature Writing concluding that depletion of nature was evident and the human response should be to conserve that which remained of the wild. John Muir (b.1838-d.1914) reveled in all of nature's expressions and immersed himself, and thus humans, into the dynamic flow of life. To him, nature was full and teeming with life. Once immersed, he contributed the foundation of a perspective of preservation in the face of despoliation and misuse of nature.

Industrialization and rapid settlement in the United States worked together to establish the awareness that natural resources were being used up, native peoples were fading, and factory towns were replacing once pristine frontiers. Nature Writers reacted

with a defiant love of nature, a reaction against the 17th century rise of philosophical dualism and against the kind of bias against nature that grew from mechanistic science. They protested the neglect of nature and the human heart.

Mary Austin's (b.1868-d.1934) writings revealed landscapes inhabited with people fully in the picture as a part of nature. She saw the character and behavior of humans as a product of the unique character of the land--the "inscape" shaped by the landscape--in contrast to others who have proposed that inscape shapes the landscape (Dansereau, 1973). Included also was a deep sense of the "holy" in the natural world and a sense of the sacredness of place. Her message was that Nature is alive today--originary and world-formative--and that we are a part of it. Henry Beston (b.1888-d.1968) brought the tradition close to the raw elements. Hinting of ecological conscience and consciousness, his writing revealed humanity as sick as a result of alienation from nature.

In response to rapid depletion of wilderness, Nature Writing inspired the development of a movement to conserve, preserve, and finally, to restore natural wildness. Ultimately, ecological ethics emerged from the unique historical confluence of forces. And as for ethics, Nature Writers believed that we can be ethical only in relation to something we can see, feel, understand, or love (Leopold, 1949).

From Aldo Leopold's (b.1886-d.1948) sense of human obligation to the land and all that lives in it emerged an ecological ethic and the foundation of the present day environmental/ecological movement. Rachel Carson's (b.1907-d.1964) powerful critique of the effect on nature of unbridled industrialization and development combined scientific

explication with parable and narrative descriptions of pollution. Through her work, Nature Writing moved closer to describing a world that needed something beyond conservation, beyond preservation--that is, restoration. Her writing was a "wake-up call."

Edward Abbey (b.1927-d.1989) offered a bold description of humans as part of nature, not above or below, but fully participating. He was audacious in his interactions with nature, seeking raw essence and truth by testing and interacting boldly with creatures and plants. His apparent hard and brutal mysticism masked a tender love of nature.

Gary Snyder's (b.1930) writing developed a sense of place as bioregion, a true delineation of the boundaries of our various homes. In the abstract, place cannot inspire our loyalty, our love. Snyder's message is that in real landscape, known and loved, place can save us.

Terry Tempest Williams (b.1955) presented a full and rich story of human intimacy with nature. In her writing, the reader is drawn in as a participant. Williams saw the land degraded and fragmented; communities degraded and fragmented; and, consequently, souls degraded and fragmented. In nature, she sought a refuge, a place where a remnant may live, a place body and soul may call home.

Woven throughout the Nature Writing literature are the writings of our earliest Nature Writers, the Native Americans. Their writing persistently reminds readers of the loss we have sustained as a result of uncaring affiliation with nature--a loss most acutely experienced and recognized by the indigenous cultures in this country.

Today the compelling message of the Nature Writers is that an ecological necessity exists for our return home to nature. The tradition, once descriptive and contemplative, has become the message of our times encompassing physical as well as spiritual well-being. The potential impact of the message is profound, touching both the institutions of science and of education. According to Gary Snyder (1955),

> Nature Writing has the potential of becoming the most vital, radical, fluid, transgressive, pansexual, subductive, and morally challenging kind of writing on the scene. In becoming so, it may serve to halt one of the most terrible things of our time--the destruction of species and their habitats and the elimination of some living beings forever. (pp. 170-171)

Values in Science and Science Education

The practice of science is a highly social human activity involved in and affected and modified by the cultural and historical milieu. The kinds of questions asked by science, methods of investigation used, and means of interpretation applied all reflect values of the time, place, and persons participating. The values associated with today's science are often described as values that Western culture has long associated with males, so-called masculine values such as objectivity, competition, and control. Others describe feminine values, often hidden, that nevertheless play an important role in the practice of science, values such as receptivity, cooperation, and care.

Scientists whose practice acknowledges the place of intuition, error, relatedness, and emotion, or who describe their work in these terms, are often excluded from the scientific literature and their achievements may go unrecognized. Nobel Laureate Barbara McClintock, for example, was long unrecognized, some say, because she

described her work in terms of empathy, intimacy, and even love. She described a "feeling for the organism" (Keller, 1983, p. 198):

> I found that the more I worked with [chromosomes under the microscope] the bigger and bigger they got, and when I was really working with them I wasn't outside, I was down there. I was part of the system. . . . It surprised me because I actually felt as if I were right down there and these were my friends. (Keller, 1985, p. 165)

On the other hand, physicist Albert Einstein acknowledged emotion in his work and did not go unnoticed. However, the human side of Einstein was largely undisclosed and discussion of his work rarely reflects what is evident in the following statement: "The state of feeling which makes one capable of such achievement is akin to that of the religious worshipper or of one who is in love" (Einstein, 1973, p. 86).

Whatever the private practice of science, a prevailing public view--also true for some scientists--is that science is either entirely impersonal, objective, and dispassionate, or the passion of its practice comes from a desire to dominate and control nature as inert, passive, and waiting to be manipulated or penetrated.

Values in Science Education

Despite evidence that the private practice of science may include fun, humor, beauty, joy, drama, love, and passion, the practice of science education largely appears to reflect the world view those outside of science have of the practice of science, that is, the view that nature is wholly determinate and objective and science is value-free.

Russell Gough (1996), Professor of Philosophy at Pepperdine University, attributes the myth of value-neutral education largely to philosophers whose views assumed no objective value to things. He asserted,

> No objective knowledge exists apart from a tradition's world view or ideology that sustains it. . . . [Those who] profess value-neutrality are imparting values under the guise of imparting none. All institutions--educational or otherwise--are value-laden. . . . We must remember and combat that great myth of the View from Nowhere, the view that "objectivity" means coming from nowhere in particular. (Gough, 1996, pp. 4-13)

Such a notion is theoretically and practically impossible. Therefore, Gough proposed that it is essential to uncover the ideology behind our institutions and our teaching. In summary, to get at core values, the ultimate criteria against which we judge competing ideas, methods, and behaviors, we must go through philosophy.

Values in science education are being considered partly in the context of a renewed interest in values and moral education among parents, politicians, educators, and scholars. Evidence of this renewal can be found in the popular media as well as the contents of educational and philosophical journals (Alter & Wingert, 1995; Bates, 1995; Bennett, 1993; Cohen, 1995; Coles, 1995; Etzioni, 1996; Noddings, 1995; Popov, Popov, & Kavelin, 1990; Ries, 1992; Sommerfield, 1994). Important questions being asked in this context relate to the values content or moral implications of current school curricula including student textbooks, teacher preparation, and teacher talk in the classroom.

A number of studies looked at curricula in science education and found few programs that adequately connected content with social responsibility despite the fact that

the United States is in the midst of national science education reform (Ramsey, 1993). In examining student textbooks, Munby (1976) found factual-sounding portions of text that contained no contextual reminders of values or moral perspective even though such perspectives were implicit in the content. Other researchers criticized textbooks for their strong mechanistic bias or for fostering scientism, an attitude that science is the only true and ultimate way to know (Ausubel, 1966; Eastman, 1969; Kolbourn, 1976). In student textbooks, Martin (1991) found gender-bias in what was intended as neutrally-presented scientific information.

Because teachers are the ultimate arbiters of classroom textbook use, studies have been conducted to investigate how science methods textbooks used to prepare teachers deal with morally-laden content or pedagogy. In one study, six science methods textbooks, including both elementary and secondary levels, were analyzed to discern the moral content (Kesselheim, 1993). The method identified text segments having explicit as well as implicit moral guidance. The study reported on the degrees of "moral avoidance" or "moral confrontation" found in the textbooks in relation to selected indices of moral or ethical controversies of our time. Noted were references to the role of the teacher, the nature of the subject, strategies for presenting the material, and possible affective student outcomes.

The analysis found the methods texts to be highly variable in the degree to which they confront the issue of moral education through science. All but one of the elementary texts appeared to support some form of "moral avoidance." One seemed to encourage

teachers to trigger moral response and reflection in students, yet warned them not to provide any guidance. Another appeared to have no reference to moral education whatever, presenting science as compartmentalized, sterile, and not connected to society. A third advised teachers that controversial issues are morally relevant only in relation to a given segment of our pluralistic political and social context--a kind of relativistic perspective. The fourth elementary methods text was found to send mixed messages to teachers about developing certain moral beliefs in children. Teachers were advised to use social conflict between students to develop rules of conduct, but at the same time cautioned to refrain from providing guidance and to let students construct the outcomes. The fifth text portrayed teachers as facilitators and advised neutrality, but juxtaposed factual information against feelings in such a way that suggested factual information is entirely and always unbiased.

The sixth text was the only one offering explicit guidance to teachers making it the teacher's responsibility to guide students. The values of science were presented as human values and teachers were advised to challenge students to consider that science can be understood differently depending upon the scientist's point of view or paradigm.

In conclusion, most of the methods texts appeared to support some form of moral avoidance. Only one appeared to support moral confrontation. Researchers concluded that the wide variation among science methods texts in their approach to moral education is a cause for concern. It appears that teachers are not being taught that values are more than matters of personal preference but that they have social implications that can clearly

be described as beneficial or not. One textbook author asserted that "education is not and ought not to be limited to learning about: there are . . . emotions to be fostered, attitudes to be developed, convictions to be encouraged, ways of acting to be promoted" (Martin, 1981, p. 78).

Science teachers both unknowingly and knowingly convey particular world views when teaching about the physical and biological world, thus shaping their students' world views. Students learn science within a context of a set of beliefs about the basic nature of reality and how one comes to know about it. Believing that the character of classroom discourse differs from the text presentation, one study identified world views projected in teacher talk; examined the links between these world views and content areas; and determined whether the world views were projected openly or hidden (Proper, Wideen, & Ivany, 1988). Specific content areas included in the study were physics, chemistry, biology, and earth science.

The teacher discourse was drawn from 55 segments of teacher talk in audio-taped lessons in secondary science classes grades 8, 9, and 10. Included were multiple lessons from each of 22 teachers. The typewritten transcripts were analyzed to identify world views.

A mechanistic or machine-like world view was dominant in both physics and chemistry. The teaching of biology had the broadest spread of world views with mechanism appearing most often followed closely by "formism" and then "organicism." Formism was described as a view based on similarity among events or objects that

indicate they are made or grow according to the same plan. Plato and Aristotle represent this world view. Organicism was described as portraying an organic integration. Finally contextualism appeared in biology at about half the rate of each of the others. Contextualism represents a pragmatic perspective, viewing events in their present context. Only earth science, in which formism was predominant, revealed no evidence of a mechanistic world view. However, the sample of earth science lessons was disproportionately small--only 5 of 54 segments of teacher talk--and may have affected the results.

Significantly, the researchers found that teachers presented world views by implication or assumption. They did not alert students that a certain conceptual framework was being used and that the topic could be viewed in other ways. Teachers simply asserted the views by embedding them in their talk about the content of the science subject.

In summary, this study found that only a limited set of world views was projected by teachers and was projected covertly rather than openly. From their results, the researchers recommended that philosophical training be offered to teachers to help them gain awareness of and openness to alternative world views. Further, they recommended that teachers openly bring a variety of perspectives to their students and present alternatives to the major paradigms, discussing the limits of each. In short, teachers need to practice in their teaching the very qualities of openness and awareness they are attempting to impart about science.

The role of teachers' value orientations to their subject matter was examined through interviews and classroom observations of four expert high school teachers in a study by Sigrun Gudmuundsdottir (1990). The four teachers taught at the same high school and were recommended by their principal as excellent veteran teachers. They were observed between 18 and 22 times over a period of five months and were interviewed extensively about their curriculum, students, and conception of their subject matter. Analysis indicated that teachers' value orientations to their subject matter influenced their choice of content, their use of the textbook, their pedagogical strategies, and their perceptions of students' instructional needs. The findings led researchers to recommend that prospective teachers be required to examine their own values toward their subject matter in comparison to multiple perspectives that are inevitably value-laden. In discovering the strengths and weaknesses of their own preferred value perspective, teachers would learn what specific value perspectives exclude or fail to explain in science. Prospective teachers should be helped to understand the influence that values have and to make informed choices in selecting the values that guide the development of their pedagogical content knowledge and their teaching practice.

Environmental Education. Rodger Bybee (1979) asserted that science education must contribute to the evolution of a society that needs new values to support an emerging ecological paradigm. Because human growth and development have resulted in unprecedented ecological degradation and fragmentation, he advocated that value issues

be incorporated into all science curricula and instruction, including environmental education.

The aim of environmental education is generally recognized to be the development of responsible environmental behavior. Students are provided opportunities to acquire knowledge, values, attitudes, commitment, and skills needed to sustain and restore the environment.

Environmental education, however, is not free from distortion by the prevailing Western paradigm. Curricula in environmental education often perpetuate a view of the earth as a resource, a laboratory, a recreation site, and so on, neglecting other possible perspectives. A number of studies linked curricular strategies in environmental education with the development of values and various world views and recommended best practices in the classroom.

Gough and Kesson (1992) found that environmental educators deeply concerned about the ecological effects of technology on the earth may inadvertently support a utilitarian view of nature. They may do so by using analytical perspectives exclusively to illustrate degradation of the earth and to justify the need for environmental concern. Such teachers believed that students who understand objectively the cause and effect of environmental problems will respond appropriately to environmental issues by changing behaviors or advocating for changed behaviors and decisions.

Conversely, in another study, the practice of environmental education was found to emphasize the teaching of attitudes and values at the expense of environmental

knowledge (Gigliotti, 1990; Iozzi, 1989). The imbalance came about because teachers believed that environmental knowledge alone was insufficient to bring about responsible environmental behavior. But this proposition may be equally applied to values education. In fact, evidence exists that values education alone may foster a notion that self-interest and personal preference are the highest considerations in personal ethics in relation to the health of the environment. Neither a knowledge-based approach nor a values-education approach in isolation is adequate.

The place of humans in the environment has been the subject of study. Jacquot (1994) found an absence of people reported by groups of individuals asked to picture their mental images of the term "environment"--as if humans were "other" than nature. Other studies of both students' and teachers' perceptions of nature found only one of six categories of perception included any of the following: humans as an equal or interdependent part of the environment; the environment having inherent worth and a right to exist; and problems in the environment as complex issues of interrelationships (Ballantyne, 1995; Wals, 1992). Other categories promoted views that environmental problems could be solved by individuals, technology, or politicians, or that the environment is solely a resource to be used or cared for by humans. From these results, researchers recommended that environmental education use a constructivist approach to help students develop environmental conceptions. This approach would encourage students to challenge inconsistencies between aspects of environmental knowledge,

values, and behavior and also to become aware of their own and alternative conceptions of the environment and environmental protection.

How to teach without "indoctrinating" has been a question of conceptual analysis off and on for many years (Degenhardt, 1986). Degenhardt argued that an indoctrinary threat does exist in "too closed" approaches to science education. Closedness of mind grows from a false view of their own discipline held by many working scientists and science teachers and perpetrated in most science lessons. The false notions are not about particular science content but are about scientific knowledge as such:

> Conversations with teachers and students of science, or a look at the methodology section of a typical textbook, reveal that most science teaching presents a more or less 'Baconian' or 'naive-inductivist' view of science . . . in which the good scientist is one who confronts nature free of bias or expectations, observes regularities, hypothesizes general laws and then looks for evidence or contrives experiments to refute or confirm these hypothesis. Almost invariably it is claimed that the basis for knowledge claims in science is empirical. (Degenhardt, 1986, pp. 114-115)

Degenhardt asserted that the whole of our culture is affected by this view and a tendency exists to judge other areas of understanding against the norm of what is thought to be science. Even though work in philosophy of science has shown that the prevailing view of science is untenable, most science teaching shows minimal awareness of this. Many do allow that results of science are tentative, but Degenhardt noted that even then the thought that a scientist is a confident and unbiased observer is generally not questioned in science education. Overlooked is the evidence that scientists not only observe through instruments but also that they observe "through" theories. Degenhardt asserted that it is impossible to observe without presuppositions or theory. In any

science, the guiding power of a body of theoretical presuppositions is great and could be considered to be constitutive elements in the "reality" observed. The story that must be told in science education, according to Degenhardt, is not a matter of straightforward generalization from observations. "Science is a highly complex partnership between guided observations and a rich body of theory" (Degenhardt, 1986, pp. 116-117). He calls for science teachers to develop ways to present a truer picture of their discipline.

Other researchers agreed:

> science teachers, who are themselves products of a science education that places a high premium on scientific knowledge and pays lip service to the history and philosophy of science, share with many practicing scientists a scant understanding of the nature of scientific knowledge itself. (ASE, 1979, p. 24)

Elkana (1970) claimed that science teachers' understanding is twenty to thirty years behind developments in the philosophy of science. Therefore, teachers promote an erroneous view if they portray scientific observation as the starting point and as a secure basis of fact and if they convey that the best observation involves only openness and childlike naiveté:

> It is the implicit philosophy of the curriculum (what one might call the "hidden science") that carries the important message about what science is and is ultimately responsible for forming children's attitudes and beliefs. . . . By insisting on the reliability and priority of observation in the scientific enterprise and by utilizing laboratory experiences based on the notion of learning by discovery, we present a distorted view of science, which is in a large measure responsible for turning children away from science. (Hodson, 1996, p. 37)

In fact, scientific observation is the highly sophisticated and skilled process of assimilating perceptions to prior knowledge and theoretical frameworks. Called for is a

teaching approach that accounts for students misconceptions, helps them understand the nature of science and develop reliable observation skills, and on that base, helps them construct new conceptions and knowledge.

A solid personal system of moral values and ethics is the foundation on which environmental values can be built. Taking into account Jean Piaget's and Lawrence Kohlberg's theories on the stages of cognitive and moral development, Michael Caduto (1983) proposed that directly teaching values in the early years is not indoctrination. Before students have developed higher powers of cognitive and moral reason or a personal value system, inculcation of sound social and environmental values is a legitimate educational strategy. However, strategies must change when students have achieved a stage of development at which they have an autonomous sense of moral reasoning. Then, appropriate educational strategies include helping them to better understand their own values and the effects of values on their behaviors. They may then help students compare their values with those most beneficial to social and environmental welfare.

As to the question of which values should be taught, Caduto points to those values that are the result of twenty-five centuries of moral reflection of religious beliefs and secular philosophies. Others have been more specific about the particular set of values that should be taught. For example, the Virtues Project presents a set of values called "virtues" drawn from a consensus of values found in the world's sacred texts (Popov et al., 1995). Brian Hall (1995) offers a set of 125 universal values common throughout all

languages and races, synthesized from philosophical, educational, and psychological literature and tested over ten years. These value sets and others are the source of constructs that underlie disciplines of academic study and ethical systems of all cultures. A subset of these values may be proposed to underlie environmental science and education.

The Two Cultures and an Ethic of Care

Two back-to-back studies investigated the hidden curriculum in both science and the humanities and offer provocative findings about the cultural gap that needs bridging between the two disciplines (Tobias, 1990; Tobias & Abel, 1990). In one study, Tobias set out to determine the classroom culture of introductory science classes. Six students and one professor from non-science fields were invited to be participant-observers in introductory physics or chemistry, recording in journals their personal encounters with the subjects. In another study, Tobias recruited fourteen university professors of science and technology to become learners in a course on poetry, exploring in writing and interviews their reactions to the material and to the process. In each case, the cross-discipline students were high achievers and had chosen their respective disciplines not because they could not achieve in the other disciplinary area, but because they believed they had a better option. Tobias' questions included the following: 1) Is there something about the way science is taught that causes the severe migration of students out of science at critical junctures in the educational process?; and 2) What makes humanities classes hard or off-putting for students of science and technology?

The humanities students taking science classes complained that the class consisted mainly of problem-solving with no interesting or inspiring exchange of ideas. Students also suffered from a lack of community, partly as a result of large class size but also from a lack of enthusiasm for the subject matter among fellow students and professors alike. They found other students fixated on grades, their own and fellow students, which engendered competition and hostility and seemed to teach students to fear cooperation because another student's achievement would be detrimental to their own. Students in physics classes observed that no one seemed interested in talking about problems conceptually. They were mired in facts and dry formulas with an absence of theory or interpretative information. Creativity was discouraged and replaced by the sense that the goal was to do the work the way the instructor did--to be trained, but not educated. In chemistry, students were not encouraged to think, but to memorize and perform. Performance came before competence. There was an absence of history and context. With one exception, the students in the science classes did very well and liked the science, but they didn't like the classes. They were left hungering for information about how the various methods they were learning had come to be, why physicists and chemists understand nature the way they do, and what were the connections between what they were learning and the larger world. The kind of attention, depth, and excitement they experienced in humanities classes was clearly lacking for them in science classes.

For the women participants, especially, the science classroom was perceived as an unfriendly place and some teachers were considered arrogant and sometimes patronizing.

Women students yearned for more cooperative and interactive modes of learning and a linkage between scientific knowledge and societal issues.

In the humanities class, students of chemistry, materials science, geology, mathematics, and physics studied Chaucer and Wordsworth in a course designed to provide an opportunity to reflect on pedagogy and classroom culture. Poetry was chosen because it is commonly seen as opposed to a scientific view. Chaucer and Wordsworth were chosen because they are each part of the established canon, but somewhat unfamiliar generally so might be considered "hard" and not part of the every day life of science. Participants kept notes about what they were noticing, what they liked and did well at, what they had difficulty with, and what they were discovering about the humanities in general.

Students complained that, in contrast to science classes, the dominant teaching mode in humanities was talk and more talk and that aural and oral interpretation were very important. No graphics or models were used to hold the learners attention. Structures of lectures and even sentences were more complicated than they were used to in science and there seemed to be no hierarchy of principles or focus to help students order the material. The sequence seemed arbitrary; the process formless. The mode seemed to be "meander and grope" (Tobias & Abel, 1990, p. 169). The most profoundly off-putting aspect of the humanities for the science students was the "absence of proof" (Tobias & Abel, 1990, p. 172). In regard to knowing an author's intentions and

meanings, the students complained that the humanist is capable of seeing things that are not there, creating significance with omissions.

Other contrasts between the two disciplines or cultures were evident. Students said that the humanities reflected on various levels of meaning, details and the global scene, in contrast to science and engineering which rarely reflected on the big picture. In science classes what counted was the "right" answer, memorizing facts, and being neat and orderly. Science students in humanities classes had difficulty coming to terms with ambiguities in poetry, stating that in science you read for what is evident on the surface and do not look for hidden meanings. The student was never sure if a new interpretation of a poem was actually new, whereas in science, it was clear when new knowledge was created. Essentially, there seemed to be a fundamental difference in how knowledge was constructed between science and humanities.

Based on the findings of the separate studies, Tobias recommended that teachers of the humanities and of science bridge the gap by adopting or adapting teaching approaches from the other "opposing" culture or discipline to provide opportunities for more students to be drawn to learn in each. Teachers of the humanities could lessen the ambiguity by providing clear criteria for acceptable interpretation and appropriate writing. Teachers of science could encourage discussion of conceptual science and development of community in the classroom. Above all, teachers in the humanities and the sciences must reach out to students and help them understand how knowledge is constructed and evaluated in each of the disciplines.

Nel Noddings (1995), Stanford University, proposed that rather than being organized around traditional disciplines, education should be organized around themes of care. The aim of education should be to encourage the growth of competent, caring, loving and lovable people. She argued against current liberal education that forces all students into narrowly prescribed curricula devoid of content they care about and in favor of greater respect for the range of human capacities. She also argued in favor of valuing the skills, attitudes, and capacities traditionally associated with women. Following Nodding's (1995) recommendations, students would be prepared to do what she calls "the work of attentive love" (p. 366). Among the themes of her proposed reorganization are life cycles and stages; a respect for all forms of honest work; love and friendship; civic responsibility; and intimate relations with others including the self, global others, plants, animals, the environment, objects, instruments, and ideas. Noddings offers six steps for beginning the transformation of curriculum and instruction: 1) Be clear and unapologetic about the goal; 2) Take care of affiliative needs; 3) Relax the impulse to control; 4) Get rid of program hierarchies; 5) Give at least part of each day to themes of care; and 6) Teach students that caring in every domain implies competence. This last recommendation by Noddings seems especially significant. To care well, we must work continuously on our competence in science and the humanities. Caring is not mushy or sentimental. "It is the strong, resilient backbone of human life" (Noddings, 1995, p. 368).

A debate ongoing in psychology questions whether females, more often than males, exhibit a "care" orientation in their moral lives. Carol Gilligan (1982) described

this orientation as a "different voice" in moral deliberation found in her recorded interviews with women. Her work challenged Lawrence Kohlberg's (1981) cognitive theory of moral development which spoke of justice and rights. However, some investigators reported hearing the voice of care in men whose life experiences of care and responsibility have been similar to women's. The idea of an ethic of care is not new. It can be found in perspectives of others such as Martin Buber (1970) in I and Thou, who distinguished between two ways of relating to other entities: an "I-Thou" mode and an "I-It" mode. According to Gilligan, ethical and spiritual life require "I-Thou" encounters. Applied in science and in education, such an ethic supports the kind of subjective knowledge and connected knowing spoken of by Belenky et al. (1986) and illustrated by Barbara McClintock's experience of knowing in science which won her a Nobel prize (Keller, 1983). The absence of community, relationship, and an ethic of care has been pointed to as a factor in turning female and minority students away from the study of science (Blake, 1993; Keller, 1985).

A way of knowing that makes knowledge personal is evident in Native American cultures whose powerful sense of community and deep connection to nature fosters an ethic of care for all beings and the earth. Vine Deloria (1992), a Lakota Sioux author and University of Colorado professor, speaks of the potential for a sustainable science created by grounding the skills of Western science in a world view that acknowledges traditional Native American conceptions of the mysterious connectedness that science knows as

Bell's Theorem. Richard Sominelli (1994) conveyed his optimism regarding the power of such a synthesis to transform environmental science:

> Environmental science is one of the most promising areas for a reconciliation between science and life to begin. It is in this new field that feeling and spirit must function alongside objective scientific skills. We look forward to the re-integration of the human heart and Western science. (p. 12)

Gough and Kessen (1992) point out that environmental educators can learn much from pre-modern cultures such as Native Americans whose very languages reflect a linear and material construction of time and "bridge the subject and object worlds" and support a caring kinship between humans and nature (Jay, 1986, p. 112). Because language is a powerful cultural text, attention to it and care in its use can nurture an innate sense of aesthetic or spiritual relationship between humans and the natural world (Mortensen, 1976).

The language of poetry has a special place in the lexicon of literature on developing an ethic of care. Poetry can foster a revitalized sense of tradition and a vision of human culture in harmony with the rest of the natural order, according to John Elder (1985) in his book Imagining the Earth. Elder focused attention on the relationships between culture and wilderness, imagination and landscape, and science and poetry. The humanities, particularly poetry, have been shown to reveal our relation to nature and "discover grounds for reconciliation in the inextricable wholeness of the world" (Elder, 1985, p. 1). In a section on "Science of the Heart," Elder (1985, pp. 161-215) asserted that poetry could carry out a realignment of Western tradition, particular poetry of the

Nature Writers, reviewed earlier in this Chapter. Nature Writing helps to bridge the gap between scientific and artistic understanding of the world. The new vision of modern science has itself contributed to creating a bridge because of its increasingly comprehensive view of physical reality. Elder described poetry in ecological terms as the "edge" or "ecotone" between humans and the rest of nature, powerful to influence the language, activities, and environmental concerns of both scientists and humanists. In the language of science,

> An ecotone is a transition between two or more diverse communities, as, for example, between forest and grassland or between a soft bottom and hard bottom marine community. . . . The ecotonal community commonly contains many of the organisms of each of the overlapping communities, and, in addition, organisms which are characteristic of and often restricted to the ecotone. Often, both the number of species and the population density of some of the species are greater in the ecotone than in the communities flanking it. The tendency for increased variety and density at community junctions is know as the "edge effect." (Elder, 1985, p. 191)

The edge effect, its oscillations and richness, is described also by the poet A. R. Ammons in his poem "One: Many."

> when I considered alone
> a record
> of the waves on the running blue creek,
> I was released into a power beyond my easy failures,
> released to think
> how so much freedom
> can keep the broad look of serenity
> and nearly statable balance. (Elder, 1985, p. 206)

Explaining how poetry becomes an ecotone, Elder (1985) again uses words of poet A. R. Ammons:

> The poetic consciousness beginning at a center works itself out by incorporation until through craft, experience, insight, etc., it brushes in a

> fulsome way against the fulsomeness of nature so that on the periphery it is so deeply spelt out that it can tangle with the coincidental. (p. 194)

According to Elder (1985), "Poetry, informed by science, learns to consider every object in the world as a universe complete in itself. And in the spiraling unity of the everywhere-centered earth, a poem too can circle its arms in motion's holding" (p. 205). In this ecotone of science and the humanities, "poets enact a circuit of healing" (Elder, 1985, p. 1).

Summary

Humans through the centuries have contemplated the nature of nature, the value of nature, and the human relationship with nature. This chapter reviewed theories and perspectives on these topics and their impact on the development of science and subsequent influence on the theory and practice of science education. Called for by the literature in science education is an approach that bridges the cultures in such a way as to impart values needed to restore intrinsic value to the Earth and Earth processes. What follows is an exploration of values that might underlie an essential ethic for such an approach to teaching science.

CHAPTER 3

Research Design and Methodology--Stage One: Nature Writers

Introduction

The purpose of this study was to identify and explore values and views that might underlie an essential ethic for teaching science. In this study, two groups of participants revealed the essence and the meaning of their relationship with nature. The outcome of the study points to a foundation of values that, if instilled in young people, might better prepare them to form, and fully participate in, communities that restore and sustain Earth.

The nature of the phenomenon studied and the scope of the study called for qualitative research. The design and procedure of the study allowed an opportunity to hear separately from two participant groups--Nature Writers and scientists--who by virtue of their vocations or avocations are among those most intimate with the natural world. The design of the study further allowed an opportunity to bring together the voices of the two groups revealing either dissonance, resulting from disparate values or views, or resonance, resulting from a concurrence of values or views.

This chapter is divided into two main sections. The first section sets the qualitative research context of the study and establishes the two-stage study design. The second section describes the procedures used in Stage One of the study and the results that are carried forward from the Nature Writers to the scientists in Stage Two. Stage Two procedures and results are described in Chapters 4 and 5.

Research Design

This qualitative study rests on the philosophical perspective of phenomenology which asks the following question: What is the essence and structure of this phenomenon for these people (Bogdan & Biklan, 1992; Cresswell, 1994; Maykut & Morehouse, 1994). In this study, the essence, or the experience itself, was explored by asking: How do those closest to the Earth experience the phenomenon of nature? The structure, or the conception of the experience, was explored by asking: What meaning do they give to their experience?

Phenomenology

Not only is the qualitative approach to this study a phenomenological one, but the exploration itself focuses on accounting for the intersubjectivity of human experience of phenomena in the natural world, whether the experience with nature occurs in reverie, recreation, reflection, or in scientific research. Edmund Husserl (1931/1960), a German philosopher and the central figure in the origins of the phenomenological movement, and later, Maurice Merleau-Ponty (1962), a French philosopher, believed that humans naturally perceive subjectively when interacting with nature or the constituents of nature. They discerned an affinity between humans and other natural entities or sentient bodies, creating a reciprocity or a silent ongoing conversation. Both philosophers believed that there is a reality that transcends consciousness, but one that also remains dependent on our perceptual consciousness--a paradox indeed--and one that calls into question a widely-held assumption of science that we experience a single, wholly determined,

objective reality. Understanding the ways Nature Writers and scientists experience and understand the nature of nature, the value of nature, and the human relationship with nature is central to this study.

Similarly, I, as the researcher in this study, must account for the subjectivity inherent in my role as the human instrument gathering and interpreting data. The "indwelling" posture of conducting qualitative research leads naturally to an intersubjectivity between me and the participants, me and the topic (Maykut & Morehouse, 1994, p. 25). Beyond that natural bent inherent in qualitative research, this study is subject to the values and biases I bring with me regarding the participants and the topic. Thirty years of professional experience--half in humanities teaching, among other subjects, literature of Nature Writers, and half working with scientists in national laboratories--links me closely with both groups of participants in this study. My intense interest in uncovering ways to bridge the two cultures--humanities and science--links me closely with the topic of the study, as does my deep and long exploration of the essence and meaning of my personal relationship to nature. On the other hand, my training and practice in working with textual data in science and humanities and my experience working with hundreds of scientists and students prepare me to successfully bracket my values and biases where necessary. More importantly, my training and experience prepare me to take advantage of my biases and values to help shape the interpretation of the data and enrich this study. This, too, is a quality of qualitative research (Maykut & Morehouse, 1994).

Methodology

The design of this study and the procedures for collecting and analyzing data brought forth in one continuous process the values and views of two groups of participants who have in common an uncommon intimacy with the natural world. A two-stage, modified Delphi method in four rounds was used for collecting data. The Delphi questionnaires served as the interview or focus group common in qualitative research. This method is especially suited to the elusive and subjective character of the topic as well as to the characteristics of the participants in the study.

Stage One comprised the first "round" of the Delphi method and involved the Nature Writers. Stage Two, described in Chapters 5 and 6, included all subsequent rounds and involved the scientists. The perspectives of the Nature Writers, which resulted from the first round, were taken to the scientists in the second and subsequent rounds. Finally, the results from each participant group were brought together in a recursive process, one with the other, to determine findings.

Procedures for Stage One: Nature Writers

To learn from the first group of participants--the Nature Writers--I turned to their writings, particularly their journals, essays, and poetry, which fall into the genre of literature called Nature Writing. Procedures used for collecting and analyzing data from writings of the Nature Writers are described in this section.

Round 1: Nature Writers

The results of this study are grounded in the values and views of Nature Writers who are the first participant group of the two-stage modified Delphi process. Assumed is that the writers used written communication to organize representations and explanations of their personal experiences in nature. The actual writings of the Nature Writers--journals, essays, or poetry--were treated as literary documents subject to the perspectives of literary criticism, including content analysis, to reveal answers to the following questions: 1) How do Nature Writers relate to the Earth?; 2) What essential values are evident in that relationship?

Participant Selection

Although the field of Nature Writing is vast and crosses continents and centuries, I selected for this study American Nature Writers only--including Native American writers. In the United States, the Nature Writing tradition emerged from a confluence of historical forces and paradoxes: Romanticism versus science; and industrialization versus expansion into the wilderness. This tradition and these forces and paradoxes in Nature Writing are not unrelated to the tradition, forces, and paradoxes in the development of American education institutions and systems. With that in mind, I selected American Nature Writers believing they would provide a context for making a particularly strong connection to an essential ethic for teaching science, toward which this study is aimed.

The American Nature Writers selected are a chronological representation from early America to today. They depict the development of the Nature Writing tradition

from early descriptions of nature apart from humans to today's writings that reflect the deepest integration of humans within the natural world. They also chronicle the development of American environmental consciousness and conscience.

Included are a variety of types of Nature Writing literature written in and about a variety of bioregions or geographical locations. Some of the Nature Writers included in the study are both literary artists and scientists or naturalists. Others are scientists who also write; while still others are clearly writers first and lay no claim to scientific understandings or perspectives. Not all works by any one writer were included in this study. Selected writings of each of the following Nature Writers were examined:

Henry David Thoreau (1817-1862)
Ralph Waldo Emerson (1803-1892)
Walt Whitman (1819-1892)
John Burroughs (1837-1921)
John Muir (1838-1914)
Mary Austin (1868-1934)
Aldo Leopold (1886-1948)
Henry Beston (1888-1968)
Rachel Carson (1907-1964)
Loren Eisley (1907-1977)
Lewis Thomas (1913-
Edward Abbey (1927-1989)
E. O. Wilson (1929-
Gary Snyder (1930-
Wendell Berry (1934-
N. Scott Momaday (1934-
Stephen Jay Gould (1941-
Kathleen Moore (1943-
Annie Dillard (1945-
Gretel Ehrlich (1946-
Joy Harjo (1953-
Terry Tempest Williams (1955-

While other sources reviewed in the literature (Chapter 2) helped point to possible categories of values derived from the Nature Writers, the results of this study emerged from the words of the Nature Writers themselves.

Procedures for Collecting Data and Analyzing Content

Procedures for collecting data and analyzing the content of Nature Writing were emergent, intuitive, and interpretive in much the same as is qualitative research as a

whole. In the content analysis, meaning was inferred from critical reflection on words, phrases, paragraphs, and passages of text written by Nature Writers. Made challenging because the genre of Nature Writing blurs distinctions generally made between scientific and aesthetic or imaginative writing, the interpretation of their writing required subtle reading and re-reading.

The content analysis procedure used in this study bears resemblance to the constant comparative method of analyzing textual data, i.e., segmenting data, developing coding categories, and generating patterns or themes (Gall, Borg, & Gall, 1996). As I read each document, I noted on index cards the words, phrases, sentences, paragraphs, or passages from the text that seemed to convey the writer's relationship with nature. Specifically, two categories of text emerged and were recorded: 1) descriptions of actions, incidents, situations, or physical or imagined landscapes--the essence of the experience; and 2) descriptions of thoughts, reflections, feelings, or imaginations about the experience--the meaning or conceptualization of the experience.

As I progressed through the documents--some 10,000 to 12,000 pages--I sorted and re-sorted, reflecting on possible categories represented on the index cards. Meaningful clusters reflecting values inherent in the writers' relationships with nature emerged. Through a process of adjusting and redefining to account for overlap and ambiguity, the list of values categories grew from an initial five or six to more than twenty and, finally, by the time the reading was complete, settled into a list of fifteen

values that seem to represent most strongly--repeatedly and across the array of writers--the essence and meaning of the Nature Writers' relationships to the natural world.

The meaning of the text finally was assumed to reside in the minds of the writers and the reader. Although the resulting interpretations were grounded in the text, they were carefully weighed in relation to the context in which they were written and the context in which they were read, taking into account variations in meaning across time, space, and cultures.

Results: Statements of Values

Fifteen statements of values resulted from the data collection and analysis. In the following pages, these values are presented and supported with examples of text taken directly from the writings of the Nature Writers and used in the development of the values statements. Hundreds of text excerpts were collected as data, of which only a few representative examples appear here.

- Curiosity: Zest for knowing the truth of how the universe operates and of what the natural world is made; excitement in learning something new

Henry David Thoreau (1992), New England naturalist and father of American Nature Writing, said, "I suspect that the child plucks its first flower with an insight into its beauty and significance which the subsequent botanist never retains" (p. 18).

Some retain that child-born curiosity, as did Thoreau, and among them was Edward Abbey (1968), who was overtaken by curiosity in the desert of Utah when he saw two garter snakes in a kind of ritual mating dance on his verandah:

> A shameless voyeur, I stare at the lovers, and then to get a closer view run outside and around the trailer to the back. There I get down on hands and knees and creep toward the dancing snakes, not wanting to frighten or disturb them. I crawl to within six feet of them and stop, flat on my belly, watching from the snake's-eye level. Obsessed with their ballet, the serpents seem unaware of my presence. . . . They intertwine and separate, glide side by side in perfect congruence, turn like mirror images of each other and glide back again, wind and unwind and simultaneously they discover me, prone on my belly a few feet away. The dance stops. After a moment's pause the two snakes come straight toward me, still in flawless unison, straight toward my face, the forked tongues flickering, their intense wild yellow eyes staring directly into my eyes. For an instant I am paralyzed by wonder; then, stung by a fear too ancient and powerful to overcome I scramble back, rising to my knees. The snakes veer and turn and race away from me in parallel motion, their lean elegant bodies making a soft hissing noise as they slide over the sand and stone. I follow them for a short distance, still plagued by curiosity. (pp. 20-21)

Walt Whitman (1882), writing from America's heartland, described his curiosity and eagerness to learn of bumblebees:

> Nature marches in procession, in sections, like corps of an army. All have done much for me, and still do. But for the last two days it has been the great wild bee, the bumblebee, or "bumble," as the children call him. As I walk, or hobble, from the farmhouse down to the creek, I traverse...the choice habitat of those crooning, hairy insects. Up and down and by and between the rails, they swarm and dart and fly in countless myriads. As I wend slowly along, I am often accompanied with a moving cloud of them. They play a leading part in my morning, mid-day, or sunset rambles, and often dominate the landscape in a way I never before thought of--fill the long land, not by scores or hundreds only, but by thousands. Large and vivacious and swift, with wonderful momentum and a loud swelling perpetual hum, varied now and then by something almost like a shriek, they dart to and fro, in rapid flashes, chasing each other, and (little things as they are) conveying to me a new and pronounced sense of strength, beauty, vitality, and movement. Are they in their mating season? Or what is the meaning of this plenitude, swiftness, eagerness, display? As I walked, I thought I was followed by a particular swarm, but upon observation I saw that it was a rapid succession of changing swarms, one after another. (Finch & Elder, 1990, pp. 240-241)

For Henry Beston (1928/1992), who lived in the "outermost" house on a beach at Cape Cod, "living in outer nature keeps the senses keen" (p. 81). He said,

> We lose a great deal . . . when we lose this sense and feeling for the sun. When all has been said, the adventure of the sun is the great natural drama by which we live, and not to have joy in it and awe of it, not to share in it, is to close a dull door on nature's sustaining and poetic spirit. (Beston, 1928/1992, p. 81)

For Kathleen Moore (1995), who writes of "riverwalking" in the Northwest region, curiosity is an art:

> I wish to speak a word for the art of poking around. . . . The kind of poking around I am interested in advocating must be done outdoors. It is a matter of going into the land to pay close attention, to pry at things with the toe of a boot, to turn over rocks at the edge of a stream and lift boards to look for snakes or the nests of silky deer mice, to kneel close to search out the tiny bones mixed with fur in an animal's scat, to poke a cattail down a gopher hole. . . . People who poke around have seeds in their socks and rocks in their pockets. . . . Poking around is more capricious than studying, but more intense than strolling. It's less systematic than watching, but more closely focused. Unlike hiking, it has no destination. Above all, poking around is not as serious as walking, the noble art so eloquently advocated by Henry David Thoreau. (pp. 27-28)

"The whole point is that poking around is good in itself, like music, or moonrise" (Moore, 1995, p. 31).

- Wonder: Appreciation for, even delight in, the beauty, diversity, and complexity of nature; the joy of discovery

Closely related to curiosity is wonder. Rachel Carson (1955), a marine biologist and the first great American critic of environmental pollution, was almost outside herself with wonder along the beach one night:

> I surprised a small ghost crab in the searching beams of my torch. . . . There was no sound but the all-enveloping primeval sounds of winds

> blowing over the water and sand, and of waves crashing on the beach There was no other visible life--just one small crab near the sea. Suddenly I was filled with the odd sensation that for the first time I knew the creature in its own world--that I understood, as never before, the essence of its being. In that moment time was suspended; the world to which I belonged did not exist. I might have been an onlooker from outer space. The little crab alone with the sea became a symbol that stood for life itself--for the delicate, destructible, yet incredibly vital force that somehow holds its place amid the harsh realities of the inorganic world. (Finch & Elder, 1990, pp. 522-523)

"How strange and wonderful is our home, our earth," said Edward Abbey (1968), who wrote of the Utah desert and of what he called the "shock of the real."

> For a little while we are again able to see, as the child sees, a world of marvels. For a few moments we discover that nothing can be taken for granted, for if this ring of stone is marvelous then all which shaped it is marvelous, and our journey here on earth, able to see and touch and hear in the midst of tangible and mysterious things-in-themselves, is the most strange and daring of all adventures. (Abbey, 1968, p. 37)

Other Nature Writers would appear to agree with Abbey, including Stephen J. Gould (1989), noted Harvard paleontologist, who found wonder in the smallest of creatures:

> The animals of the Burgess Shale are holy objects--in the unconventional sense that this word conveys in some cultures. We do not place them on pedestals and worship from afar. We climb mountains and dynamite hillsides to find them. We quarry them, split them, carve them, draw them, and dissect them, struggling to wrest their secrets. We vilify and curse them for the damnable intransigence. They are grubby little creatures of a sea floor 530 million years old, but we greet them with awe because they are the Old Ones, and they are trying to tell us something. (p. 52)

Wonders of nature range from the microscopic to the telescopic, the latter described below by Lewis Thomas (1983), medical doctor and "biology watcher."

> The overwhelming astonishment, the queerest structure we know about so far in the whole universe, the greatest of all cosmological scientific puzzles, confounding all our efforts to comprehend it, is the earth. We are only now beginning to appreciate how strange and splendid it is, how it catches the breath, the loveliest object afloat around the sun, enclosed in its own blue bubble of atmosphere, manufacturing and breathing its own oxygen, fixing its own nitrogen from the air into its own soil, generating its own weather at the surface of its rain forests, constructing its own carapace from living parts: chalk cliffs, coral reefs, old fossils from earlier forms of life now covered by layers of new life meshed together around the globe, Troy upon Troy. Seen from the right distance, from the corner of the eye of an extraterrestrial visitor, it must surely seem a single creature, clinging to the round warm stone, turning in the sun. (p. 17)

N. Scott Momaday (1966), a Kiowa Indian of the southwest, described the wonder of the landscape on the rim of the Valle Grande:

> Dappled with the shadows of clouds and vibrant with rolling winter grass. The clouds were always there, huge, sharply described, and shining in the pure air. But the great feature of the valley was its size. It was almost too great for the eye to hold, strangely beautiful and full of distance. Such vastness makes for illusion, a kind of illusion that comprehends reality, and where it exists there is always wonder and exhilaration. (p. 20)

- Respect: A sense of the intrinsic value of the natural world in all its variety and forms, human and nonhuman, aside from its utility and despite its wildness and mystery

Asking no favors from nature, true respect goes beyond taming nature for human use. Thoreau (1937) said,

> In wildness is the preservation of the world. Every tree sends its fibers forth in search of the wild . . . the most alive is the wildest . . . the unsympathizing man regards the wildness of some animals, their strangeness to him, as a sin; as if all their virtue consisted in their tamableness. . . . What we call wildness is a civilization other than our own. . . . In, short, all good things are wild and free. (pp. 672-678)

Mary Austin (1932/1960), writing of the landscape between Death Valley and the High Sierras, appears to agree with Thoreau: "He who does not understand that the wildness of mountains serves us far more than their tameness, understands very little" (p. 393).

Edward Abbey (1968), sought to meet nature face-to-face, to "look at and into a juniper tree, a piece of quartz, a vulture, a spider, and see it as it is in itself, devoid of all humanly ascribed qualities" (p. 6).

Respect is a value demonstrated by Nature Writers, not only in actions but in admonishments to readers. Said Henry Beston (1928/1992), "Whatever attitude to human existence you fashion for yourself, know that it is valid only if it be the shadow of an attitude to Nature" (p. 218).

That "attitude" of respect extended to other animals, with whom many Nature Writers expressed a kinship, as did Walt Whitman (1959):

> I think I could turn and live with animals, they're so placid and self contain'd,
> I stand and look at them long and long.
> They do not sweat and whine about their condition
> They do not lie awake in the dark and weep for their sins,
> They do not make me sick discussing their duty to God,
> Not one is dissatisfied, not one is demented with the mania of owning things,
> Not one kneels to another, nor to his kind that lived thousands of years ago,
> Not one is respectable or unhappy over the whole earth.
> So they show their relations to me and I accept them,
> They bring me tokens of myself, they evince them plainly in their possession.
> I wonder where they get those tokens,
> Did I pass that way huge times ago and negligently drop them? (p. 47)

Respect for other beings and their ways is reflected in the writing of Kathleen Moore (1995), who wrote of the rivers of the Northwest, and described one of their heroic inhabitants:

> The loon is a straight-laced, pin-striped, buttoned-down, black and white bird with a marking around its neck that looks like a preacher's necktie. Its name comes from an old Scandinavian word that means I weep, and it's no wonder. The loon is an ancient bird, a strong diver, an efficient hunter and surely a good citizen, floating mute on tundra ponds. But what makes the loon a hero in my eyes is that sometimes, on clear nights in the spring and late in fall, the loon lifts itself with strong wing beats to stand almost upright on the water, raises its head to the sky, and lets loose with wild, maniacal laughter that rolls across the pond and bounces, yowling and exultant, against the farther shore. (p. 160)

- Reverence: Awe or adoration of the natural world that transcends respect for biogeochemical interconnections and acknowledges deep spiritual connection

"The stars awaken a certain reverence," said Ralph Waldo Emerson (1905), New England naturalist and Thoreau's inspiration (p. 58).

Many Nature Writers felt a deep spiritual connection, even communion, with nature. For Mary Austin (1903/1988), the landscape resonated with the "inscape," affecting the inner being. Speaking of the desert she said, "Its treeless spaces uncramp the soul" (Austin, 1903/1988, p. 53). She described one of the many experiences with nature throughout her lifetime that inspired reverence:

> Long before men set up an anthropomorphic deity there was a state, easily met among mountains, called holy, being whole with the experienceable universe. . . . There must have been a time, for man, when the impact of the mountains on his sense was too direct for clear distinctions of seeing or hearing. . . . It comes back here for definite, memorable moments, as when, in the early winter months, the sunset light has a way of passing invisibly through space, to break on the first object it encounters, tree-tops or the clinkered crests of extinct craters, into a glory of gold and

> hyacinthine color. Thus the whole *Sangre de Cristo* fills with secret fire, rose flame, shadowed with violet, deepening at its base to the hue of the spirit's most poignant mystery . . . holy, holy, holy . . . The moment comes and goes. (Austin, 1924/1983, pp. 389-390)

Thoreau (1992) said, "in the sunshine and the crowing of cocks, I feel an illimitable holiness, which makes me bless God and myself" (p. 23).

Walt Whitman (1959) revered the miracle of life, saying,

> I believe a leaf of grass is no less than the journey-work
> of the stars,
> And the pismire is equally perfect, and a grain of sand, and
> the egg of the wren,
> And the tree-toad is a chef-d'oeuvre for the highest,
> And the running blackberry would adorn the parlors of
> heaven,
> And the narrowest hinge in my hand puts to scorn all machinery,
> And the cow crunching with depress'd head surpasses any
> statue,
> And a mouse is miracle enough to stagger sextillions of infidels. (p. 46)

Summing up the sentiment of many Nature Writers is Henry Beston (1928/1992) --with these words: "It is as impossible to live without reverence as it is without joy" (p. 216).

- Receptivity: Openness in listening and responding, allowing answers to emerge, to reveal themselves in nature, patience with the process

Common to most Nature Writers, receptivity opens the mind and the eye. Annie Dillard (1974), writing of a year in the Roanoke Valley of Virginia's Blue Ridge Mountains, described it thus:

> The secret of seeing is, then, the pearl of great price. If I thought he could teach me to find it and keep it forever I would stagger barefoot across a hundred deserts after any lunatic at all. But although the pearl may be found, it may not be sought.

> Unfortunately, nature is very much a now-you-see-it, now-you-don't affair. A fish flashes, then dissolves in the water before my eyes like so much salt. Deer apparently ascend bodily into heaven, the brightest oriole fades into leaves.
>
> It's all a matter of keeping my eyes open.
>
> The lover can see, and the knowledgeable. . . . The point is that I just don't know what the lover knows; I just can't see the artificial obvious that those in the know construct.
>
> But there is another kind of seeing that involves a letting go. When I see this way I sway transfixed and emptied. The difference between the two ways of seeing is the difference between walking with and without a camera. When I walk with a camera I walk from shot to shot, reading the light on a calibrated meter. When I walk without a camera, my own shutter opens, and the moment's light prints on my own silver gut. When I see this second way I am above all an unscrupulous observer.
>
> When I see this way I see truly. As Thoreau says, I return to my senses. . . . One day I was walking along Tinker Creek thinking of nothing at all and I saw the tree with the lights in it. I saw the backyard cedar where the mourning doves roost charged and transfigured, each cell buzzing with flame. I stood on the grass with the lights in it, grass that was wholly fire, utterly focused and utterly dreamed. It was less like seeing than like being for the first time seen, knocked breathless by a powerful glance. The flood of fire abated, but I'm still spending the power. Gradually, the lights went out in the cedar, the colors died, the cells unflamed and disappeared. I was still ringing. I had been my whole life a bell, and never knew it until at that moment I was lifted and struck. I have since only very rarely seen the tree with the lights in it. The vision comes and goes, mostly goes, but I live for it, for the moment when the mountains open and a new light roars in spate through the crack and the mountains slam. (pp. 31, 33-34)

To be receptive to nature, John Muir (1969), father of the National Park system, immersed himself in it, reveling in a "beautiful and exhilarating" storm in the California Sierras:

> When the storm began to sound, I lost no time in pushing out into the woods to enjoy it. For on such occasions Nature has always something

> rare to show us, and the danger to life and limb is hardly greater than one would experience crouching deprecatingly beneath a roof. . . . The Silver Pines were now the most impressively beautiful of all. Colossal spires 200 feet in height waved like supple goldenrods chanting and bowing low as if in worship. . . . The force of the gale was such that the most steadfast monarch of them rocked down to its roots with a motion plainly perceptible when one leaned against it. Nature was holding high festival, and every fiber of the most rigid giants thrilled with glad excitement.
>
> I drifted on through the midst of this passionate music and motion. Toward midday, it occurred to me that it would be a fine thing to climb one of the trees to obtain a wider outlook and get my ear close to the Aeolian music of its topmost needles. . . . After cautiously casting about, I made choice of the tallest of a group of Douglas Spruces that were growing close together like a tuft of grass, no one of which seemed likely to fall unless all the rest fell with it. Though comparatively young, they were about 100 feet high, and their lithe, brushy tops were rocking and swirling in wild ecstasy. I experienced no difficulty in reaching to top of this one, and never before did I enjoy so noble an exhilaration of motion. The slender tops fairly flapped and swished in the passionate torrent, bending and swirling backward and forward, round and round, tracing indescribable combinations of vertical and horizontal curves, while I clung with muscles firm braced, like a bobolink on a reed.
> I kept my lofty perch for hours, frequently closing my eyes to enjoy the music by itself, or to feast quietly on the delicious fragrance that was streaming past. (Finch & Elder, 1990, pp. 282-285)

According to Thoreau (1992), sometimes it is important "to ignore or forget all that men presume that they know, and take an original and unprejudiced view of Nature, letting her make what impression she will on you, as the first men, and all children and natural men still do" (p. 105).

Open to learning from trees, Wendell Berry (1987), a Kentucky farmer, wrote of his experience:

> I go among trees and sit still.
> All my stirring becomes quiet
> around me like circles on water.
> My tasks lie in their places

where I left them, asleep like cattle.

Then what is afraid of me comes
and lives a while in my sight.
What it fears in me leaves me,
and the fear of me leaves it.
It sings, and I hear its song.

Then what I am afraid of comes.
I live for a while in its sight.
What I fear in it leaves it,
and the fear of it leaves me.
It sings, and I hear its song.

After days of labor,
mute in my consternations,
I hear my song at last,
and I sing it. As we sing
the day turns, the trees move. (p. 5)

According to Aldo Leopold (1949), renowned conservationist and Nature Writer from upper Wisconsin, the quality of receptivity is not widely demonstrated. He said, speaking of the clamor of humans to invade wilderness, "Recreational development is a job not of building roads into lovely country, but of building receptivity into the still unlovely human mind" (Leopold, 1949, p. 177).

- Humility: Response to the natural world that acknowledges human limitations; does not draw conclusions based on partial knowledge

"Who placed us," said Thoreau (1992), lamenting our limited vision, "with eyes between a microscopic and a telescopic world?" (p. 79)

In understanding the place of humans in Darwin's scheme, Stephen J. Gould (1989) proposed that it was anything but depressing:

> Homo sapiens, I fear, is a "thing so small" in a vast universe, a wildly improbable evolutionary event well within the realm of contingency. Make of such a conclusion what you will. Some find the prospect depressing; I have always regarded it as exhilarating, and a source of both freedom and consequent moral responsibility. (p. 291)

Gary Snyder (1995), who writes of the American West from California to Alaska, enlarged our understanding of the human place in the natural order, with these words:

> The science of ecology, with its demonstrations of coevolution, symbiosis, mutual aid and support, interrelationship, and interdependence throughout natural systems, has taught us modesty in regard to human specialness. It has also taught us that our understanding of what is and is not "harmful" within the realm of wild nature is so rudimentary that we should not even bother to take sides between predators and prey, between primary green producers and detritus-side fungi or parasites, or even between "life" and "death." (p. 71)

According to Aldo Leopold (1949), our understanding of the "value of wilderness boils down, in the last analysis, to a question of intellectual humility" (p. 200). Leopold's own understanding was expanded and his environmental conscience born when, as a young man, he worked for the forest service and delighted in gunning down wolves, who were seen as threats to cattle ranchers. Coming upon an old wolf playing together with young pups, he and friends fired wildly, injuring and killing many:

> We reached the old wolf in time to watch a fierce green fire dying in her eyes. I realized then, and have known ever since, that there was something new to me in those eyes--something known only to her and to the mountain. I was young then, and full of trigger-itch; I thought that because fewer wolves meant more deer, that no wolves would mean hunters' paradise. But after seeing the green fire die, I sensed that neither the wolf nor the mountain agreed with such a view. (p. 130)

A sense of limits can open us to a "grace" profound, as described in these words of Wendell Berry (1993):

> When despair for the world grows in me
> and I wake in the night at the least sound
> in fear of what my life and my children's lives may be,
> I go and lie down where the wood drake
> rests in his beauty on the water, and the great heron feeds.
> I come into the peace of wild things
> who do not tax their lives with forethought
> of grief. I come into the presence of still water.
> And I feel above me the day-blind stars
> waiting with their light. For a time
> I rest in the grace of the world, and am free. (p. 30)

- Love: Intense attraction or devotion to the natural world; a passion for nature; a feeling for the organism

"None other than this long brown land lays such a hold on the affections," said Mary Austin (1903/1988), and "You of the house habit can hardly understand the sense of the hills" (pp. 1, 75).

Love permeates most intimate relationships with nature. The quality of love described by the Nature Writers ranges from attraction and devotion to deep passion. E. O. Wilson (1984), Harvard scientist and naturalist, said,

> You start by loving a subject. Birds, probability theory, explosives, stars, differential equations, storm fronts, sign language, swallowtail butterflies--the odds are that the obsession will have begun in childhood. The subject will be your lodestar and give sanctuary in the shifting mental universe. (p. 65)

Thoreau (1992) reminded us that "a fact stated barely is dry. . . . It must be warm, moist, incarnated,--have been breathed on at least. A man has not seen a thing who has not felt it" (p. 90).

Without this love, we are bereft. Henry Beston (1928/1992) described the absence of the object of his affection: "The world today is sick to its thin blood for lack

of elemental things, for fire before the hands, for water welling up from the earth, for air, for the dear earth itself underfoot" (p. 10).

Devotion to animals was expressed by Gretel Erlich (1985), who wrote of life in Wyoming's open spaces:

> We're comrades who save each other's lives. . . . Animals hold us to what is present: to who we are at the time, not who we've been or how our bank accounts describe us. What we may miss in human interaction here we make up for by rubbing elbows with wild animals. (pp. 62-68)

Others heard love songs, as did John Muir (1979):

> The sun shines not on us but in us. The rivers flow not past, but through us, thrilling, tingling, vibrating every fiber and cell of the substance of our bodies, making them glide and sing. The trees wave and the flowers bloom, in our bodies as well as our souls, and every bird song, wind song, and tremendous storm song of the rocks in the heart of the mountains is our song, our very own, and sings our love. (p. 92)

An eagerness to be with the beloved was expressed by some, including Kathleen Moore (1995). Standing on Alaska's Maclaren summit, viewing a "river cast in gold, melted and poured" and a glacier that "gleamed with amber light," she said,

> I had to hold myself together because the clarity of the air made me buoyant, and if I hadn't been careful, my arms would have risen to the sky in exultation, and all the air would have left my lungs, and maybe I would have caught my breath and bounded toward the beauty like a lonesome dog, wagging its whole backside with recognition and joy. (p. 155)

For Edward Abbey (1968), who expanded the definition of love, "the love of wilderness is more than a hunger for what is always beyond reach; it is also an expression of loyalty to the earth" (p. 167).

Some remain forever deeply committed to a love relationship with the Earth, as Wendell Berry described in his poem, "The Current":

> Having once put his hand into the ground,
> seeding there what he hopes will outlast him,
> a man has made a marriage with his place,
> and if he leaves it his flesh will ache to go back. (Finch & Elder, 1990, p. 61)

And, according to Henry Beston (1928/1992), the Earth, as a true lover, reciprocates:

> To all who love her, who open to her the doors of their veins, she gives of her strength, sustaining them with her own measureless tremor of dark life. Touch the earth, love the earth, honour the earth, her plains, her valleys, her hills, and her seas; rest your spirit in her solitary places. For the gifts of life are the earth's and they are given to all, and they are the songs of birds at daybreak, Orion and the Bear, and dawn seen over ocean from the beach. (p. 218)

- Relatedness: Awareness of intimate, personal involvement with the natural world; a feeling of kinship, attachment, or rapport with nature

Without a kinship with nature, we are less than human, said Henry Beston (1928/1992):

> When the Pleiades and the wind in the grass are no longer a part of the human spirit, a part of very flesh and bone, man becomes as it were, a kind of cosmic outlaw, having neither the completeness and integrity of the animal nor the birthright of a true humanity. (p. xxxv)

Loren Eisley (1957), writing of the Platte River as it moved toward the Missouri, recognized kinship as an evolutionary phenomenon. Telling of a "water brotherhood," when he freed from ice a catfish--"a yellow-green, mud-grubbing, evil-tempered inhabitant of floods and droughts and cyclones," he thereafter, saw "in many a fin and

reptile foot . . . some part of myself, that is, some part that lies unrealized in the momentary shape I inhabit" (Lynch & Swanzey, 1981, p. 61).

A rapport with nature, inspired these words of Walt Whitman (1959):

> I swear the earth shall surely be complete to him
> or her who shall be complete,
> The earth remains jagged and broken only to him
> or her who remains jagged and broken.
>
> I swear there is not greatness or power that does not
> emulate those of the earth,
> There can be no theory of any account unless it
> corroborate the theory of the earth,
> No politics, song, religion, behavior, or what not,
> is of account, unless it compare with the
> amplitude of the earth,
> Unless it face the exactness, vitality, impartiality,
> rectitude of the earth. (p. 164)

Joy Harjo (1989), of the Creek (Muscogee) tribe, describes reciprocity in her relationship with the land:

> It's true the landscape forms the mind. If I stand here long enough I'll learn how to sing. None of that country and western heartbreak stuff, or operatic duels, but something cool as the blues, or close to the sound of a Navajo woman singing early in the morning. (p. 8)

For Terry Tempest Williams (1995), who wrote of the Great Salt Lake Basin, an intimate involvement grew from her love of nature. She felt called by the land: "It is the desert that persuades me toward love" (Williams, 1995, p. 46). She explored what it means to make love to the land--to the earth, water, fire and air:

> Walking barefoot on sandstone, flesh responding to flesh . . . the palms of my hands search for a pulse in the rocks . . . I relax. I surrender. . . . The arousal of my breath rises in me like music, like love, I come to the rock in a moment of stillness, giving and receiving, where there is no partition between my body and the body of Earth.

> My fear of heights is overcome by my desire to merge. I dive into the water, deeper and deeper. . . . We are water. We are swept away. Desire begins in wetness. . . . We are moving downstream. Water. Water music. Blue notes, white notes, my body mixes with the body of water like jazz, the currents like jazz. I too am free to improvise.
>
> The fire ignites. My longing returns. When we want everything to change we call on fire. . . . The fire is aroused. The flames reach higher. . . . Do I dare to feel the white heat of my heart as a prayer? What is smoldering inside me? . . . The fire explodes. My eyes close. I allow myself to be ravished.
>
> I reclaim the sweet and simple ecstasy of breathing. . . . My body softens as I make my wish to follow my breath . . . something pulls me higher, takes hold of my spine and stretches me. . . . I kneel at the mouth where the rock lips are open, a column of wind is wafting, rushing up from the center of Earth. I try to shape a voice, to feel its words through the delicacy of my fingers. . . . I place my mouth over the opening. My belly rises and falls . . . I am dizzy. I am drunk with pleasure. There is no need to speak. Listen. Below us. Above us. Inside us. Come. This is all there is. (Williams, 1995, pp. 3-16, 19-30, 39-41, 54-58)

- Interdependence: Knowledge of the interconnectedness of organisms and their environments; a sense of the web of life, the ecological balance of nature

Most Nature Writers see themselves depending on and offering sustenance to the Earth. Rachel Carson (1962) spoke with concern:

> There are intimate and essential relations between plants and the earth, between plants and other plants, between plants and animals. Sometimes we have no choice but to disturb these relationships, but we should do so thoughtfully, with full awareness that what we do may have consequences remote in time and place. (p. 64)

Carson (1962) said these connections reflect the "web of life--or death--that scientists know as ecology." She spoke also of connections within organisms: "There is

also an ecology of the world within our bodies. In this unseen world minute causes produce mighty effects" (p 189).

John Burroughs (1908), who wrote in the Catskills of New York, told of our interconnectedness with all of life:

> We are rooted to the air through our lungs and to the soil through our stomachs. We are walking trees and floating plants. The soil which in one form we spurn with our feet, and in another take into our mouths and into our blood--what a composite product it is. . . . The iron in the fruit and vegetables we eat, which thence goes into our blood, may, not very long ago, have formed a part of the cosmic dust that drifted for untold ages along the highways of planets and suns. (p. 203)

And of a deeper interdependence, Burroughs (1908) continued:

> The babe in its mother's womb is not nearer its mother than we are to the invisible sustaining and mother powers of the universe, and to its spiritual entities, every moment of our lives. . . . Whatever is upon the earth is of the earth; it came out of the divine soil, beamed upon by fructifying heavens, the soul of man not less than his body. (p. 212)

Mary Austin (1903/1988) observed the wild creatures, stating that we "probably never fully credit the interdependence of wild creatures, and their cognizance of the affairs of their own kind" (p. 20):

> Once at Red Rock, in a year of green pasture, which is a bad time for the scavengers, we saw two buzzards, five ravens, and a coyote feeding on the same carrion, and only the coyote seemed ashamed of the company. (Austin, 1924/1983, pp. 389-390)

In speaking of death, Thoreau (1992) recognized the sustaining balance of nature:

> How enduring are our bodies, after all! The forms of our brothers and sisters, our parents and children and wives, lie still in the hills and fields round about us, not to mention those of our remoter ancestors, and the matter which composed the body of our first human father still exists under another name. (p. 13)

Acknowledging an enduring connection, Gary Snyder (1974) expressed the following commitment:

> I pledge allegiance to the soil
> of Turtle Island
> one ecosystem
> in diversity
> under the sun--
> With joyful interpenetration for all. (p. 43)

- Unity: Holistic view of nature; a sense of the oneness, wholeness, and harmony of the natural world, including humans; not limited by dual or compartmental thinking

"Everything, everything, is a whole, and a parcel of everything else" (Dillard, 1977, p. 66).

And Thoreau (1992) said: "There is something more than association at the bottom of the excitement which the roar of a cataract produces. It is allied to the circulation in our veins" (p. 46).

Thoreau's friend, Emerson (1905) expanded the definition of unity:

> Herein is especially apprehended the unity of Nature--the unity in variety--which meets us everywhere. All the endless variety of things make an identical impression. . . . A leaf, a drop, a crystal, a moment of time is related to the whole, and partakes of the perfection of the whole. Each particle is a microcosm, and faithfully renders the likeness of the world. . . . Each creature is only a modification of the other; the likeness in them is more than the difference, and their radical law is one and the same. A rule of one art, or a law of one organization, holds true throughout nature. So intimate is this Unity, that, it is easily seen, it lies under the undermost garment of nature. (pp. 53-55)

Gretel Erlich (1985) spoke of resolving duality; in her words, "Space has a spiritual equivalent and can heal what is divided and burdensome in us" (p. 14).

Sensing unity in time and space over the Nazlini Mudhills, Joy Harjo (1989) said,

> I can hear the sizzle of newborn stars, and know anything of meaning, of the fierce magic emerging here. I am witness to flexible eternity, the evolving past, and I know we will live forever, as dust or breath in the face of stars, in the shifting pattern of winds. (p. 9)

A sense of oneness with nature is described by many Nature Writers and characterized often by unexpected feelings of heightened sensitivity and awareness. Mary Austin (1932/1960) described it well:

> I must have been between five and six when this experience happened to me. It was a summer morning and the child that I was had walked down through the orchard alone and come out on the brow of a sloping hill where there was grass and a wind blowing and one tall tree reaching into infinite immensities of blueness. Quite suddenly, after a moment of quietness there, earth and sky and tree and wind-blown grass and the child in the midst of them came alive together with a pulsing light of consciousness. . . . I in them and they in me, and all of us enclosed in a warm lucent bubble of livingness . . . inclusive awareness of each for the whole. . . . I remember the child looking everywhere for the source of this happy wonder, and at last she questioned--"God?"--because it was the only awesome word she knew. Deep inside, like the murmurous swinging of a bell, she heard the answer, "God, God . . . " How long this ineffable moment lasted I never knew. It broke like a bubble again--only never quite the same. (p. 371)

Lifting the experience to heights of spiritual wholeness and harmony, she described a

> warm pervasive sweetness of ultimate reality, the reality first encountered so long ago under the walnut tree. Never to go away again; never to be completely out of call. . . "Nearer than hands or feet" . . . Only the Christian saints have made the right words for it, and to them it came after long discipline of renunciation. But to [me] it just happened. Ultimate, immaterial reality. You walk into it the way one does into those wisps of warm scented air in hollows after the sun goes down; there you stand motionless, acquiescing, I do not know how long. It has nothing to do with time nor circumstance; no, nor morals, nor behaviors. It is the only true and absolute. (Austin, 1932, p. 198)

From his experience of unity, John Burroughs (1908) concluded:

> All things are alike or under the same laws--the rocks, the soil, the soul of man, the trees in the forest, the stars in the sky. We have fertility, depth, geniality, in the ground underfoot, on the same terms upon which we have these things in human life and character.
>
> The doors and windows of the universe are all open; the screens are all transparent. We are not barred or shut off; there is nothing foreign or unlike; we find our own in the stars as in the ground underfoot; this clod may become a man; yon shooting star may help redden his blood. (pp. 206, 212)

N. Scott Momaday (1976) spoke from his heritage of a pervasive unity of all things, all beings:

> I am a feather on the bright sky
> I am the blue horse that runs in the plain
> I am the fish that rolls, shining, in the water
> I am the shadow that follows a child
> I am the evening light, the lustre of meadows
> I am an eagle playing with the wind
> I am a cluster of bright beads
> I am the farthest star
> I am the cold of the dawn
> I am the roaring of the rain
> I am the glitter on the crust of the snow
> I am the long track of the moon in a lake
> I am a flame of four colors
> I am a dear standing away in the dusk
> I am a field of sumac and the pomme blanche
> I am a gaggle of geese in the winter sky
> I am the hunger of a young wolf
> I am the whole dream of things. (p. 8)

- Care: Concern for well-being and flourishing of all life; close attentiveness to the things/beings of nature; pleasure and patience in getting to know them

Patient attention to nature characterized many of the Nature Writers and stimulated care and concern for all life. Writings of Annie Dillard (1974) exhibit this value:

> I am sitting under a sycamore by Tinker Creek. I am really here, alive on the intricate earth under trees. But under me, directly under the weight of my body on the grass, are other creatures, just as real, for whom also this moment, this tree, is "it." Take just the top inch of soil, the world squirming right under my palms. In the top inch of forest soil, biologists found "an average of 1,356 living creatures present in each square foot, including 865 mites, 265 springtails, 22 millipedes, 19 adult beetles and various numbers of 12 other forms. . . . Had an estimate also been made of the microscopic population, it might have ranged up to two billion bacteria and many millions of funge, protozoa and algae--in a mere teaspoonful of soil." The chrysalids of butterflies linger here too, folded, rigid, and dreamless. I might as well include these creatures in this moment, as best I can. My ignoring them won't strip them of their reality, and admitting them, one by one, into my consciousness might heighten mine, might add their dim awareness to my human consciousness, such as it is, and set up a buzz, a vibration like the beating ripples a submerged muskrat makes on the water, from this particular moment, this tree. Hasidism has a tradition that one of man's purposes is to assist God in the work of redemption by "hallowing" the things of creation. By a tremendous heave of his spirit, the devout man frees the divine sparks trapped in the mute things of time; he uplifts the forms and moments of creation, bearing them aloft into that rare air and hallowing fire in which all clays must shatter and burst. Keeping the subsoil world under trees in mind, in intelligence, is the least I can do. (p. 94)

"Being there"--this feature of caring is often rewarded with new sights and insights, also described by Annie Dillard (1974):

> The mockingbird took a single step into the air and dropped. His wings were still folded against his sides as though he were singing from a limb and not falling, accelerating thirty-two feet per second, through empty air. Just a breath before he would have been dashed to the ground, he unfurled

> his wings with exact, deliberate care, revealing the broad bars of white, spread his elegant, white-banded tail, and so flouted onto the grass. I had just rounded a corner when his insouciant step caught my eye; there was no one else in sight. The fact of his free fall was like the old philosophical conundrum about the tree that falls in the forest. The answer must be, I think, that beauty and grace are performed whether or not we will or sense them. The least we can do is try to be there. (p. 8)

True caring sees the essence of the creature, not just its utility, as expressed by Thoreau (1992):

> The legislature will preserve a bird professedly not because it is a beautiful creature, but because it is a good scavenger or the like. This, at least, is the defense set up. It is as if the question were whether some celebrated singer of the human race . . . did more harm or good, should be destroyed or not, and therefore a committee should be appointed, not to listen to her singing at all, but to examine the contents of her stomach and see if she devoured anything which was injurious to the farmers and gardeners, or which they cannot spare. (p. 74)

Thoreau (1992) advocated for caring enough to truly know the essence of the animal:

> Surely the most important part of an animal is its anima, its vital spirit, on which is based its character and all the peculiarities by which it most concerns us. Yet most scientific books which treat of animals leave this out altogether, and what they describe are as it were phenomena of dead matter. What is most interesting in a dog, for example, is his attachment to his master, his intelligence, courage, and the like, and not his anatomical structure or even many habits which affect us less. If you have undertaken to write the biography of an animal, you will have to present to us the living creature, i.e., a result which no man can understand, but only in his degree report the impression made on him. Science in many departments of natural history does not pretend to go beyond the shell; it does not get to animated nature at all. A history of animated nature must itself be animated. (p. 75)

For beauty beyond our senses, Mary Austin (1903/1988) advised patience: "One must learn to spare a little of the pain of inexpressible beauty, not to spend all one's purse in one shop. There is always another year, and another" (p. 73).

Close attention to nature affects the observer, said the Nature Writers, among them Gretel Erlich (1985) who said, "Everything in nature invites us constantly to be what we are" (p. 84).

And the Earth cares for itself, as well. Thoreau (1992) spoke of the "friendliness" of nature: "The seed in the ground tarries for a season with its genial friends there; all the earths and grasses and minerals are its hosts, who entertain it hospitably, and plenteous crops and teeming wagons are the result" (p. 70).

- Cooperation: Attitude and behaviors of collaboration, flexibility, and sharing; sees harmony as a fundamental force in survival and adaptation of nature

According to Wendell Berry (1972), cooperation and sharing are endemic for "any solitary act is a work of community" (p. 53).

E. O. Wilson (1984), described the division of labor of leafcutter ants:

> The foraging workers, about as big as houseflies can slice leaves but are too bulky to cultivate the almost microscopic fungal strands. The tiny gardener workers, somewhat smaller than this printed letter I, can grow the fungus but are too weak to cut the leaves. So the ants form an assembly line, each successive step being performed by correspondingly smaller workers, from the collection of pieces of leaves out of doors to the manufacture of leaf paste to the cultivation of dietary fungi deep within the next. (pp. 32-33)

Genuine altruism can be found in nature as well; Lewis Thomas (1992) described such an experience:

> Among the most intensely social species it is a commonplace event, part of any day's work, for one individual member to sacrifice his life in aid of the community. The honey bees, for instance, who must eviscerate themselves because of the hive, are bona fide altruists in biological terms. It is, in a perfectly straightforward sense, self-preservation, since what is being preserved are the genes of the particular bees that do the defending

> and stinging. In biology, the preservation and persistence of one's genes represent reproductive success, and therefore evolutionary success. Behavior of this kind would naturally be naturally selected in the course of Darwinian evolution. (p. 153)

Henry David Thoreau (1992) aptly expressed his response to nature's cooperative behaviors:

> I feel slightly complimented when Nature condescends to make use of me without my knowledge, as when I help scatter her seeds in my walk, or carry burs and cockles on my clothes from field to field. I feel as though I had done something for the common weal, and were entitled to board and lodging. (p. 22)

Thoreau (1992) spoke also of the benefits of nature-inspired cooperation among humans:

> What a sublime drama we might enact if we would be joint workers and a mutual material. Why go to the woods to cut timber to display our art upon, when here are men as trees walking? The world has never learned what men can build each other up to be, when both master and pupil work in love. (p. 25)

Our ignorance may deprive us of these benefits, Wendell Berry (1972) laments:

> We do not understand the earth in terms either of what it offers us or of what it requires of us, and I think it is the rule that people inevitably destroy what they do not understand. Most of us are not directly responsible for strip mining and extractive agriculture and other forms of environmental abuse. But we are guilty nevertheless, for we connive in them by our ignorance. We are ignorantly dependent on them. We do not know enough about them; we do not have a particular enough sense of their danger. Most of us, for example, not only do not know how to produce the best food in the best way--we don't know how to produce any kind in any way. Our model citizen is a sophisticate who before puberty understands how to produce a baby, but who at the age of thirty will not know how to produce a potato. (p. 77)

- Responsibility: Concern about the likely consequences of behaviors that affect the natural world; consideration of future generations; commitment to make the world a better place

Nature, according to Henry Beston (1928/1992), has an ethic of its own. If an ethic, then a creed, based on a principle stated by Aldo Leopold (1949): "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise" (pp. 224-225). But, said Leopold (1949), "We can be ethical only in relation to something we can see, feel, understand, love, or otherwise have faith in" (p. 214).

Wendell Berry (1982) spoke of the grief that may come when we act without responsibility:

> Gravity is grace.
> All that has come to us
> has come as the river comes,
> given in passing away.
> And if our wickedness
> destroys the watershed,
> dissolves the beautiful field,
> then I must grieve and learn
> that I possess by loss
> the earth I live upon
> and stand in and am. (pp. 42-43)

Said Mary Austin (1903/1988),

> Man is a great blunderer going about in the woods, and there is not other except the bear makes so much noise. Being so well warned beforehand, it is a very stupid animal, or a very bold one, that cannot keep safely hid. The cunningest hunter is hunted in turn, and what he leaves of his kill is meat for some other. That is the economy of nature, but with it all there is not sufficient account taken of the works of man. There is no scavenger that eats tin cans, and no wild thing leaves a like disfigurement on the

> forest floor. . . . It takes man to leave unsightly scars on the face of the earth. (pp. 20, 57)

Effects of irresponsibility are described by Edward Abbey (1968): "Original sin, the true original sin, is the blind destruction for the sake of greed of this natural paradise which lies all around us" (p. 167).

Commitment to future generations must be made, according to John Burroughs (1908), or we suffer consequences:

> One cannot but reflect what a sucked orange the earth will be in the course of a few more centuries. Our civilization is terribly expensive to all its natural resources; one hundred years of modern life doubtless exhausts its stores more than a millennium of the life of antiquity. (p. 204)

To make the world a better place, Wendell Berry (1972) said that all must be involved for all are responsible:

> But the environmental crisis rises closer to home. Every time we draw a breath, every time we drink a glass of water, every time we eat a bite of food we are suffering from it. And more important, every time we indulge in, or depend on, the wastefulness of our economy--and our economy's first principle is waste--we are causing [emphasis in original] the crisis. Nearly every one of us, nearly every day of his life, is contributing directly to the ruin of this planet. A protest meeting on the issue of environmental abuse is not a convocation of accusers, it is a convocation of the guilty. That realization ought to clear the smog of self-righteousness that has almost conventionally hovered over these occasions, and let us see the work that is to be done. In this crisis it is certain that every one of us has a public responsibility. (p. 74)

- Imagination: Conceptual powers of imagery, even fantasy, to help envision, create, predict, and guide behaviors, progress, and possibilities

Nature Writers, as most artists, often look at one thing and see another. N. Scott Momaday (1969) wrote of nature inspiring a new perspective:

> Loneliness is an aspect of the land. All things in the plain are isolate; there is no confusion of objects in the eye, but one [emphasis in original] hill or one tree or one man. To look upon that landscape in the early morning, with the sun at your back, is to lose the sense of proportion. Your imagination comes to life, and this, you think, is where Creation was begun. (Finch & Elder, 1990, p. 775)

While sitting near his favorite trees, a "great oak--sturdy, vital, green," and near a tulip tree, "tall and graceful, yet robust and sinewy," Walt Whitman's (1882) imagination took over:

> I had a dream-trance . . . in which I saw my favorite trees step out and promenade up, down and around, very curiously--with a whisper from one, leaning down as he passed me, "we do all this on the present occasion, exceptionally, just for you." (Finch & Elder, 1990, pp. 244-245)

Can powers of imagination redress wrongs of the past? Wendell Berry (1993) unveils a landscape:

> I dream an inescapable dream
> in which I take away from the country
> the bridges and roads, the fences, the strung wires,
> ourselves, all we have built and dug and hollowed out,
> our flocks and herds, our droves of machines.
>
> I restore then the wide-branching trees.
> I see growing over the land and shading it
> the great trunks and crowns of the first forest.
> . . . Like the afterimage of a light that only by not
> looking can be seen, I glimpse the country as it was.
> All its beings belong wholly to it. They flourish
> in dying as in being born. (p. 22)

According to Burroughs (1908), the greatest imagination is matched by nature:

> We need not translate ourselves in imagination to some other sphere or state of being to find the marvelous, the divine, the transcendent; the gross visible world, hanging like an apple on the bough of the great cosmic tree, and swelling with all the juices and potencies of life, transcends anything we have dreamed of super-terrestrial abodes. (p. 211)

Loren Eisley (1957) was nearly overcome by a dream made real in imagination:

> One night on the twentieth floor of a midtown hotel I awoke in the dark and grew restless. On an impulse I climbed upon the broad old-fashioned window sill, opened the curtains and peered out. It was the hour just before dawn, the hour when men sigh in their sleep, or, if awake, strive to focus their wavering eyesight upon a world emerging from the shadows. I leaned out sleepily though the open window. I had expected depths, but not the sight I saw.
>
> I found I was looking down from that great height into a series of curious cupolas or lofts that I could just barely make out in the darkness. As I looked, the outlines of these lofts became more distinct because the light was being reflected from the wings of pigeons who, in utter silence, were beginning to float outward upon the city. In and out through the open slits in the cupolas passed the white-winged birds on their mysterious errands. At this hour the city was theirs, and quietly, without the brush of a single wing tip against stone in that high, eerie place, they were taking over the spires of Manhattan. They were pouring upward in a light that was not yet perceptible to human eyes, while far down in the black darkness of the alleys it was still midnight.
>
> As I crouched half asleep across the sill, I had a moments illusion that the world had changed in the night, as in some immense snowfall, and that if I were to leave, it would have to be as these other inhabitants were doing, by the window. I should have to launch out into that great bottomless void with the simple confidence of young birds reared high up there among the familiar chimney pots and interposed horrors of the abyss.
>
> I leaned further out. To and fro went the white wings, to and fro. There were no sounds from any of them. They knew man was asleep and this light for a little while was theirs.
>
> Around and around went the wings. It needed only little courage, only a little shove from the window ledge to enter that city of light. The muscles of my hands were already making little premonitory lunges. I wanted to enter that city and go away over the roofs in the first dawn.
>
> I drew back carefully into the room. I dressed then and went back to my own kind. . . . I will never forget how those wings went round and round, . . . To see from an inverted angle, however, is not a gift allotted merely to the human imagination. I have come to suspect that within their degree it

> is sensed by animals, though perhaps as rarely as among men. The time has to be right; one has to be, by chance or intention, upon the border of two worlds. And sometimes these two borders may shift or interpenetrate and one sees the miraculous. (Finch & Elder, 1990, pp. 526-527)

- Intuition: Ability to sense and follow hunches or leads that seem promising, that resonate with available information; trust that a relaxed, playful mind fosters new insights

In the following poem, Turtle Island, Gary Snyder's mind played at the interface of science and nature, revealing insights of human evolution:

> science walks in beauty:
>
> nets are many knots
> skin is border-guard, a pelt is borrowed warmth;
> a bow is flex of a limb in the wind
> a giant downtown building
> is a creekbed stood on end.
>
> detritus pathways. "delayed and complex ways
> to pass the food through webs"
>
> maturity. stop and think. draw on the mind's
> stored richness. memory, dream, half-digested
> image of your life. "detritus pathways"--feed
> the many tiny things that feed and owl.
> send heart boldly traveling,
> on the heat of the dead & down. (Elder, 1985, p. 189)

Mary Austin (1932/1960) described an intuitive grasp of knowledge that came about through a series of experiences with nature that "stole insensibly" into her thoughts:

> [I] would be watching the dew slip under the clover stems, or the white webby moons of spider webs made thick with diamond drops, and around her [me] would steal a sense of innumerable bright events, of tingling and unattempted possibilities; there would be a sense of swelling, of billows coming and going, lifting and dying away--[I] began to know the billowing sense as the pressure of knowledge, all the knowledge in the world, pulsing just out of [my] reach. It came up inside [me], [I] was

> uplifted with it, rocked upon it--there were times when [I] could discern within it, dimly, the shapes of specific knowledges. (pp. 153-54)

She further described this intuitive sense as a

> stream of knowingness which ever since adolescence I had felt going on in me, supplying deficiencies, affording criterions of judgment, creating certainties for which no warrant was to be found in my ordinary performance. (Austin, 1932/1960, pp. 230-231)

Henry Beston's (1928/1992) intuitive sense was expansive, as large as the universe itself. He felt

> a sense that the creation is still going on, that the creative forces are as great and as active today as they have ever been, and that tomorrow's morning will be as heroic as any of the world. Creation is here and now. So near is man to the creative pageant, so much a part is he of the endless and incredible experiment, that any glimpse he may have will be but the revelation of a moment, a solitary note heard in a symphony thundering through debatable existences of time. Poetry is as necessary to comprehension as science. (Beston, 1928, pp. 216-217)

And how do we communicate with the Earth? Terry Tempest Williams (1991) offered this possibility:

> How do we correspond with the land when paper and ink won't do? How do we empathize with the Earth when so much is ravaging her? The heartbeats I felt in the womb--two heartbeats, at once, my mother's and my own--are heartbeats of the land. All of life drums and beats, at once, sustaining a rhythm audible only to the spirit. I can drum my heartbeat back into the Earth, beating, hearts beating, my hands on the Earth--like a ruffed grouse on a log, beating, hearts beating--like a bittern in the marsh, beating, hearts beating. My hands on the Earth beating, hearts beating. I drum back my return. (p. 85)

Summary

This chapter described the qualitative research context, design and overall methodology of this study. Included also was a description of the procedures and results

of Stage One of the study. Results reveal values that appear to be essential to Nature Writers in their relationship with the natural world. Bringing forward the values and views of the Nature Writers to scientists produced results that are particularly provocative, useful, interesting, and revealing as is shown in Chapters 4 and 5.

CHAPTER 4

Methodology--Stage Two: Scientists

Introduction

Stage One of this study comprised the first "round" of the Delphi method and involved the Nature Writers as described in Chapter 3. To learn from the scientists in Stage Two, I used a Delphi method in three rounds, which, along with the procedures used for learning from the Nature Writers, make up the "modified" Delphi procedure used in this study. The "modification" is that the first round of the Delphi was considered to be the process of collecting data from the Nature Writers by seeking answers to specific questions posed during close reading of their writings. These "answers" were taken to the scientists in the form of questionnaires. Stage Two included all subsequent rounds and involved the scientists. Finally, the results from each participant group were brought together in a recursive process, one with the other, to determine findings.

This chapter is divided into two main sections. The first section reviews the Delphi method, including previous studies that inform the rationale for using Delphi in this study. The second section describes the questionnaires sent to scientists and the procedures for analyzing data. Data analysis and results appear in Chapter 5.

Delphi Method

Definition and Description

Delphi is a communications structure and research method that involves written, often anonymous, response to carefully designed questions, feedback of individual and/or

collective response, and opportunity for any respondent to modify an earlier judgment (Delbecq, Van de Ven, & Gustafson, 1975). Delphi addresses the issue of determining judgment that lies somewhere between factual knowledge on the one hand and speculation on the other. The method elicits and refines judgments, insights, wisdom, or opinions of members of a group without bringing them together in face-to-face interaction. Thus, the Delphi method is also particularly useful for involving experts who are geographically distant from one another and cannot easily be brought together physically.

Fundamental to an understanding of Delphi is the work of Lewin (1943, 1958), who showed that interaction among group members prior to decision-making and the forming of judgments is important, but that open discussion among members of a group often moves group positions toward uniformity and established norms. His conclusions were later supported by Van de Ven (1974) who found that group interaction tends toward high variability in member and leader behavior, falling into ruts in discussion, generating a low number and quality of ideas, generalizing, conforming to group pressure, avoiding tasks, socializing, avoiding conflict and withdrawing, short problem focus, inequality of member contribution, and little sense among participants of closure, accomplishment, or motivation to continue. These findings call for a method of interaction that allows individual group members to exchange information about beliefs, arguments, and facts without imposing individual judgments on each other.

As a controlled feedback method, Delphi may avoid many of the process characteristics that often are problematic when groups interact to form judgments or make decisions. According to Norman C. Dalkey (1969), a pioneer in developing and using Delphi, its use minimizes biasing effects of dominant individuals, of irrelevant communications, and of group pressure toward conformity. Compared to group interaction, the Delphi method yields high-quality and high-specificity results, allows freedom not to conform, and supports controlled problem focus, task-centeredness, equality of respondent contribution, independent judgments, and a high sense among respondents of closure and a moderate sense of accomplishment and motivation (Delbecq et al., 1975). However, according to a comparison study of the characteristics of Delphi with face-to-face interaction, no universally applicable rule can be applied (Turoff & Linstone, 1975). Performance in accomplishing group communication tasks depends highly on the specific task in relation to the organizational structure.

Dalkey (1969) described the thinking that established a niche for Delphi in the scope of procedures used for making decisions or forming consensus. He categorized information used to make decisions along a scale from "knowledge," or highly confirmed assertions based on strong evidence, to "speculation," or assertions that have little or no evidence. In between lay a broad area for which some basis for belief exists, but not enough to be called knowledge. This he called "opinion," a fuzzy middle area that deals with products of wisdom, insight, common sense, intuition, and similar intellectual

processes. While the dividing lines between the three areas are admittedly fuzzy, Delphi appears to deal best with this middle area.

Helmer (1967) felt that Delphi was a valid procedure for making decisions about the future because it effectively used informed intuitive judgment. Such decisions, he declared, are inevitably made based on personal expectations of individuals rather than on the basis of well-established theory, for no theory appears adequate. The alternative to Delphi, in his view, is that we throw up our hands in despair and wait until we have an adequate theory enabling us to deal with socioeconomic or political problems as confidently as we do problems with physics or chemistry. His conclusion was that Delphi fills the niche of providing a means of obtaining relevant intuitive insights from experts with the least amount of contamination.

Review of Selected Previous Studies

The foundational work which first defined the Delphi method was done by Olaf Helmer and his colleagues at the Rand Corporation in the 1950s and 1960s (Dalkey, 1969; Helmer, 1967). Delphi was originally used as a process for technological forecasting. Its use has broadened through the years to a wide range of program planning and administration including evaluating strengths and weaknesses of systems, identifying problems, predicting outcomes, and determining values, competencies, and criteria.

Almost all early Delphi studies in education were reported by Judd (1973) to be confined to administrative matters. A conclusion was that using Delphi in education could "be as barren as most of the paperwork which traditionally suffocates educational

bureaucracies" (Turoff & Linstone, 1975, p. 82). Delphi could be useful in a deeper context as an educational tool, but at the time of Judd's study, it was being used merely to support an entrenched bureaucracy which "feeds on well-structured procedures and questionnaires of all kinds" (Turoff & Linstone, 1975, p 82). However, later application of the Delphi method in education began to demonstrate its value for substantive matters.

Over time, the use of Delphi broadened as did the areas in which it was applied. While early studies by Dalkey (1969) did not establish that Delphi is useful for value judgments, a later study by Dalkey and Rourke (1971) supported the conclusion that Delphi procedures can effectively process value material as well as factual material. In this study, groups of college students were asked to rate lists of value categories they considered important to higher education and the quality of life. Analysis of results showed, among other things, that the number of changes and degree of convergence for value judgments were comparable to similar indices for factual judgments. This finding supported earlier conclusions regarding the usefulness of the Delphi method for areas that tend to be displaced toward opinion or speculation, which includes most value judgments.

In a series of studies to determine what qualities or values are needed in specific types of employment, Delphi was used to specifically identify and rank characteristics "Big Eight" firms need in accountants, thus informing the schools of accounting regarding appropriate curricula (Dinius & Rogow, 1988). In this study, a panel of ten personnel management experts provided opinions on the qualities that firms consider significant in selecting entry-level employees and the relative importance of these various

qualities. Results were found to be consistent with perceptions of employer views and were substantiated by the results of similar studies (Cook, 1994).

In 1991, Stahl found the Delphi method to be a viable solution for helping educators reach consensus on a project that required the complete backing of all those involved. In one large metropolitan school district, administrators sought a method to help educators agree on a common set of criteria for adopting or developing a thinking skills program for gifted students. A plethora of possible program definitions and criteria existed and made it particularly challenging to ensure equal consideration of input from all those concerned. The Delphi method proved to be the height of decision-making diplomacy in this situation. A sixteen member panel of experts, representing all perspectives, rank-ordered 10 definitions of critical thinking and 25 critical thinking characteristics in a three-round Delphi procedure. The consensus of four definitions and sixteen characteristics became the accepted criteria for selecting the program.

A modified Delphi study was used by human resource managers from U.S.-based firms listed in FORTUNE's Global 500 who served as an expert panel to identify which international business competencies were important and unimportant for students of international business (Zeiliff, 1993). A consensus was reached on ratings for forty-eight competencies including competencies related to social and cultural factors and values.

In a recent Delphi application, a panel of 55 educators, business people, and other distinguished experts formed a panel and participated in a Delphi procedure to name the most important knowledge, skills, and behaviors that K-12 students must develop to

prosper in the 21st century (Uchida, Cetron, & McKenzi, 1996). A high level of consensus was achieved in three rounds on the "absolutely essential" academic, personal, and civic skills and knowledge, many of which were holistic and cross disciplinary.

Two studies in science education used the Delphi method to identify teaching competencies and cognitive skills, respectively, in secondary school science teachers (Chiapetta, 1978; Simpson & Brown, 1977). None were reported that identify essential values or an ethic for teaching science.

This sampling of the application of the Delphi method supports its use in this study: To identify values and views essential to Nature Writers and scientists in their relationship with the natural world.

Features of the Delphi Method

Although Delphi is a kind of technology based on the notion that "two heads are better than one," it eliminates committee, focus group, or other face-to-face interactions typically used to bring groups to consensus. In the Delphi procedure, individual, isolated participants are presented in writing with questions on a particular topic. Through successive iterations, participants respond independently in writing, first to the questions and then, in successive rounds, to information derived from earlier responses and summarized for all respondents. The summarized information may be either or both quantitative or qualitative. Through two, three, or more rounds of controlled feedback, individual judgments are pooled and a group opinion is aggregated. The process is complete when the responses of the group have stabilized, that is, when individual

members no longer revise their previous judgments in significant ways. That is not to say that participants will come to a consensus, but that, after a sufficient number of rounds, the patterns or groupings of diverging or converging opinions will be evident.

The Delphi format may be varied considerably in its design and implementation depending upon the problem being investigated. It may also be varied during the implementation if the results indicate that variations will elicit more useful or complete information from respondents.

The feedback to respondents from round to round may vary. Experiments by Dalkey (1969) generated much insight into the nature of the group information process and helped determine the varying effects of differing kinds of feedback between rounds. Feedback can include statistical information, such as feedback of the median of the individual responses, quartiles of the distribution, or individual percentile in the distribution of responses. Qualitative information, such as responses from participants when asked to formulate reasons for their opinions, also may be provided from round to round. Self ratings of confidence regarding the topic may be used to help determine the validity of the aggregate group opinion resulting from a Delphi process.

The overall time of the process may vary depending upon the number of rounds and how quickly the respondents follow through from round to round, generally a factor of their involvement and motivation. Often, dunning strategies are needed to encourage timely response. The minimal time recommended for a Delphi process is about 45 days. If adequate time is not possible, Delphi should not be used.

Participants in a Delphi study are selected by nominators knowledgeable of the particular topic of study and in positions that afford them knowledge of potential expert participants. According to Delbecq et al. (1975), participants should be from among those who feel personally involved in the problem and have a level of expertise that might contribute significantly to the study. They must also have a level of interest in the outcome that is likely to sustain their motivation to complete the study through several iterations. The number of respondents in a group may vary depending upon the problem to be resolved. If the group is homogenous, ten-to-fifteen respondents may be enough. According to Delbecq et al. (1975), given a homogenous group, any more than 30 well-chosen participants is not likely to increase the range or diversity of the outcome.

Other areas of variation in the design and implementation of the Delphi include whether a respondent group is anonymous, the kind of question used to obtain information from the respondent, and procedures used to aggregate judgments of the respondent group.

Rationale for Using Delphi in this Study

In addition to qualities of the Delphi method discussed earlier, this model of data collection is well suited to the elusive and subjective character of this study and especially suited to the second participant group, the scientists. Leading to this conclusion are the following: 1) the topic of the study; 2) the mode of delivery and response; and 3) the source of the initial questions presented to the scientists.

The topics of values or ethics are typically not ones readily discussed among scientists--particularly in relation to their work. In the culture of science, discussing such topics requires a degree of candor that scientists may believe opens them to criticism, if not professional jeopardy. The anonymity and isolation of participants in a Delphi process diminishes that concern for it provides a protective environment that may foster candor and trust (Delbecq et al., 1975). (It is important to note, however, that most of the scientists with whom I worked for more than fifteen years personally demonstrated values that belie their reluctance to openly discuss them.)

Responding to questions about the topics of values and ethics also requires from participants a level of concentration, involvement, care, and precision not generally supported by typical group interactions for building consensus or making decisions. The Delphi method allows for the quality and quantity of time needed to consider such a topic. Participants can respond when convenient, pondering questions and reflecting at will within a prescribed span of time, generally five-to-ten days for each round.

Also particularly suited to the purpose of the study, the study topic, and the scientists as a participant group, is the fact that writing is the delivery mode of the initial questions, the feedback to participants between rounds, and the mode of response by the participants. The writing process allows, even requires, a degree of precision in language, thus in meaning, beyond what may typically be attained in face-to-face discussions or interviews. The Delphi method is more demanding than typical group discussions for it requires that the participant formulate thoughts in writing, a process that requires

reflection and care. According to Delbecq et al. (1975), the process of thinking through the complexity of the topic produces a high quality of ideas. Furthermore, scientists are accustomed to making careful notations and preparing clearly written communications about their work.

Using writing as the delivery mode also supports the modified procedure used in this study, a modification that has in effect treated a portion of the literature review--the views of Nature Writers in relation to the natural world--as the first round of the Delphi to be presented to scientists. Face-to-face interactions between Nature Writers and scientists are highly unlikely, considering first that many of the Nature Writers are no longer living, and, second that the two cultures are rarely in proximity.

An additional reason the Delphi method is well suited for this study is that the scientists are geographically dispersed and cannot be easily brought together physically. Scientists connected to the nation's national laboratories make up the group of participants for this stage of the study. Those laboratories and their adjacent or partner universities are located in every region of the United States and, therefore, are not likely to come together in one location at one time.

Limitations of Delphi Method

Among the limitations of the Delphi method noted in the literature, a number apply to this study. Most researchers caution that it is especially challenging to avoid ambivalent wording when preparing statements for the questionnaires and synthesizing participant's comments. Vague or easily misinterpreted wording can lead to confusion.

Two participants in this study called attention to confusing wording in the first questionnaire. The wording was clarified for the second questionnaire. I support the advice offered by one researcher to pretest the questionnaire on "any willing guinea pigs" to be found.

Delbecq et al. (1975) also point out that certain characteristics of the Delphi may inhibit decision-making performance in some cases. Though I have no evidence that these characteristics inhibited performance by the participants in this modified Delphi study, I considered the possibility of the following: 1) the lack of opportunity for social-emotional feedback in the Delphi communication process might give participants a feeling of detachment; 2) lack of opportunity for verbal clarification or comment on the feedback report might create interpretation difficulties for participants; and 3) handling conflicting or incompatible ideas on the feedback report by simply pooling and adding the votes meant that conflicts were not resolved. To account for these possible inhibitions, "rewards" were included in the feedback letters (e.g., encouraging words, small visual objects meant to encourage participation). Participants were invited to call with questions, and included in feedback reports all conflicting comments in addition to simply providing numerical summaries.

Procedures for Stage Two of this Study: Scientists

The design of this study and the procedures for collecting and analyzing data brought together the values and views of two groups of participants who have in common an uncommon intimacy with the natural world. To learn from the first group of

participants--the Nature Writers--I turned to their writings, particularly their journals, essays, and poetry, which fall into that genre of literature called Nature Writing. Procedures used for collecting and analyzing data from writings of the Nature Writers are described in Chapter 3.

To learn from the scientists, I used a Delphi method in three rounds, which, along with the procedures used for learning from the Nature Writers, make up the "modified" Delphi procedure used in this study. The resulting list of values statements were imbedded in the initial questionnaire presented to the scientists. In effect, the scientists' first "round" of the Delphi could be thought of as a second round of a typical Delphi procedure. The scientists, questionnaires sent to scientists, and procedures for analyzing data are described in this section.

Selection of Nominators and Participants

For this study, nominators were selected from among the directors of science education programs at U.S. Department of Energy National Laboratories and research facilities. I know the nominators as a class of individuals whose knowledge and experience prepare them to readily identify participants who meet the criteria specified. Nominators were from the following laboratories or facilities:

- Argonne National Laboratory; Argonne, Illinois
- Associated Western Universities; Salt Lake City, Utah
- Idaho National Energy Laboratory; Idaho Falls, Idaho
- Lawrence Berkeley Laboratory; Berkeley, California
- Lawrence Livermore National Laboratory; Livermore, California
- Los Alamos National Laboratory; Los Alamos, New Mexico
- National Renewable Energy Laboratory; Golden, Colorado
- Oak Ridge Institute for Science Education; Oak Ridge, Tennessee

- Oak Ridge National Laboratory; Oak Ridge, Tennessee
- Pacific Northwest National Laboratory; Richland, Washington
- Sandia National Laboratories; Albuquerque, New Mexico
- Sandia National Laboratories/California; Livermore, California
- Savannah River Ecology Laboratory; Aiken, South Carolina

Nominators were each asked to nominate three-to-seven scientists who, in their opinion, have the following qualities--as stated in the letter of request sent to nominators:

- Are seasoned scientists, successful in their fields and experienced enough to reflect on what makes a good scientist and on the enterprise and progress of science and its meaning to the quality of our lives.

- Feel personally involved in the challenge we as a nation face to teach science well in elementary and secondary schools. This quality may be demonstrated by activities such as participation as a mentor to teachers or students (K-12) in a laboratory or field setting; service on science education standard-setting activities, or involvement in a community or school science education reform effort.

Additional criteria conveyed in the body of the letter included the need to include scientists with special interest in earth and environmental sciences and to seek diversity in terms of gender and ethnicity.

Sixty-four potential participants were nominated. The first questionnaire was sent out to all those nominated along with a form requesting biographical and other information (see Appendix A). Potential participants were also assured that their names, place of work, and data would be held confidential. Of the sixty-four, twenty-five elected to participate by completing and returning the first questionnaire. The number of returns reflects a return rate of thirty-nine percent and exceeds the goal of ten-to-fifteen participants set out in the project proposal.

The twenty-five participants included six women and nineteen men, a fair representation of the ratio of men to women who work as scientists in the national laboratory system. Included also were two African Americans, two Hispanic Americans, and one American Indian--a slight over-representation of the percentage of ethnic minority groups in the population sampled. Represented were all regions of the continental United States including participants from the following states: Idaho, Washington, Colorado, Arizona, New Mexico, Illinois, Iowa, Tennessee, South Carolina, and New York. Experience as a scientist ranged from three to forty-five years; nineteen participants had fifteen or more years experience. Listed below are the primary major and sub-categories of science disciplines represented among the participants.

- Chemistry: biochemistry, chemical engineering; pollution prevention, environmental chemistry (organic)
- Biology: anatomy/cytogenetics; radiation biology; microbiology, biotechnology
- Ecology: aquatic ecology, plant ecology, radiation ecology, microbial ecology, terrestrial ecosystems, wildlife research, fisheries
- Physics: physics, systems engineering, bio/physics, solid state physics, theoretical physics
- Other: Engineering; neuroscience, industrial/organizational psychology.

First Questionnaire

In Stage Two of the modified Delphi method, data were collected by asking scientists to respond independently in writing to carefully designed questions based primarily on results of Stage One. The procedure began with a two-part questionnaire (see Appendix A), the first part of which was intended to elicit answers to the following

question: Do scientists validate what Nature Writers say? After the first questionnaire, scientists responded through successive iterations to feedback information, qualitative and quantitative, derived from their combined earlier responses and summarized for all. Through three rounds of controlled feedback, individual judgments were pooled and a range of group opinions was aggregated.

In the first questionnaire, each of the fifteen values statements that emerged from the Nature Writers was presented to the scientists asking that they rate each value's importance to their work as a scientist and to the science education of young people according to a scale provided. Scientists were also asked to provide comments or justifications to support their ratings.

The second part of the questionnaire sought insight into how scientists relate to the natural world or to the constituent parts of nature that receive their attention and focus. As with the Nature Writers, questions asked of the scientists were designed to explore the essence and the structure of their experience and relationship with the phenomenon of nature. Included with the questionnaire was a page of brief excerpts from the writings of Nature Writers and scientists describing relationships with the natural world (see Appendix A). These excerpts were intended to stimulate the study participants to recall "stories" of their own. Following is part two of the questionnaire.

II. What has been your direct experience with nature?

A. At any time or place in your life, or while in laboratory or field work, have you ever had a direct experience in nature, or working with the constituents of nature, that you would describe as transcendent, spiritual, relational, or humanistic, or an experience that brought you to a sense of oneness with nature or to profound ethical or moral concern,

strong attachment, passion, joy, or love? If so, please briefly describe that experience, tell when in your life and where it occurred, and answer the questions that follow.

B. How was this experience important to your understanding of the natural world, ecosystems, or the earth? Please describe.

C. How was this experience important to your development as a scientist? Please describe.

The questionnaire was tested on three volunteer respondents who represent the education levels, content background, and experience of the participants. Each respondent recommended changes, which were subsequently made, to the format and wording of the questionnaire.

Twenty-five scientists, described earlier, responded to the first questionnaire. Percentages, mean scores, and group ranking were computed on the ratings of values. Comments, justifications, and "stories" were summarized. Several scientists also made comments not related to the values but related to the process and the wording of the questionnaire. These suggestions were taken into account in the second questionnaire.

Second Questionnaire

The second questionnaire presented to each scientist 1) a quantitative summary table of combined percentage ratings of all scientists on each of the fifteen values, 2) their individual ratings, and 3) a compilation of comments made by all scientists to justify ratings. Each also received a copy of his or her individual "story" describing an experience in nature. Scientists were asked to review the comments, the compiled ratings of values, and their individual ratings, and to indicate for each rating whether they agreed

with the previous rating or wished to make a change. Each was also asked to read over the story previously submitted and was encouraged to elaborate or revise, as desired.

Responding to the second questionnaire, ten scientists made a total of nineteen changes in ratings, all toward the mean score; eleven scientists elaborated or revised their stories. All twenty-five scientists responded, including three who had no changes to make and validated their previous responses by telephone or electronic mail.

Third Questionnaire

The third questionnaire included only a report on value ratings that fell outside the inter-quartile range of the computed median for the group of scientists. Each scientist having one or more ratings outside the inter-quartile range of responses on the second questionnaire was given an individual report on the group median, the inter-quartile range, and the scientist's individual rating of the value. They were asked to reconsider the value in light of comments, also enclosed, made by all scientists to justify ratings of that value. Two options were offered: Either the scientist could revise the previous rating or the scientist could retain the previous rating and provide a reason for thinking the rating should be that much lower or higher than the majority judgment of the group. The third questionnaire was sent to scientists who had one or more ratings that fell outside the inter-quartile range.

Responding to the third questionnaire, eight scientists made a total of nineteen changes in ratings, seventeen of which were toward the median. Fifteen scientists

provided reasons for retaining previous ratings of values remaining outside the median of the group of scientists.

Data Analysis

In addition to computing mean and median scores for the ratings of values and rank-ordering the values, I analyzed scientists' comments on the values and their stories of experiences with nature. An emergent, constant comparative method was used for determining clusters of meaning, themes or story elements, and a typology for displaying the results.

Summary

This chapter reviewed the Delphi Method and the participants in and procedures used in Stage Two of this study. Patterns and interesting comparisons that emerged from the data collection are described in Chapter 5.

CHAPTER 5

Presentation and Analysis of Data--Stage Two: Scientists

Introduction

In this study, values and views of two select groups of participants were revealed by data collected through a two-stage, modified Delphi process. The following question was to be answered: What values are held by those most intimate with the natural world, among them Nature Writers and scientists? In Stage One, values and views of the Nature Writers were revealed as described in Chapter 3. In Stage Two, these values were brought forward to scientists, the second group of participants in the study. This chapter presents the results of the data collection and analysis of stage two, the scientists' values and views that, together with those of the Nature Writers, lead to findings that point toward an essential ethic for teaching science.

Results of Stage Two: Scientists

To learn from the second group of participants--the scientists--I used a modified Delphi procedure, described in Chapter 4, asking scientists to respond independently in writing to carefully designed questions. Scientists selected for the study are also described in Chapter 4. Statements of values synthesized from data collected from the Nature Writers were embedded in questionnaires sent to scientists. The questionnaires were designed to answer the following questions:

- Do scientists validate what Nature Writers say?

- How important do scientists believe these values are to their work and to the science education of young people?

First Questionnaire

In the first questionnaire (see Appendix A), fifteen values statements from the Nature Writers were presented to scientists asking that they rate each value's importance to their work as a scientist and to the science education of young people. Scientists were also asked to provide comments or justifications to support their ratings. Table 1 shows the scientists' rank order of the values by group mean scores and the percentage ratings according to the following scale:

3. Essential-must be included
2. Important-should be included
1. Somewhat important-would be nice, but not necessary
0. Not at all important-no need to be included.

Scientists' comments to support ratings were each brief, and as a collection, numerous. Comparing comments to ratings served as a kind of "member" check for internal validity. In general, the comments--substance and weight of frequency--validated the ratings. Comments were summarized and prepared to be included as feedback with the second questionnaire.

Table 1

First Questionnaire: Ratings and Ranking of Values

Values in Rank Order	3	2	1	0	Group Mean Scores in Rank Order
	% of Participants				
Curiosity	84	16	0	0	2.84
Receptivity	76	24	24	0	2.80
Responsibility	60	28	8	4	2.44
Imagination	48	48	0	4	2.40
Intuition	52	36	12	0	2.40
Interdependence	48	44	4	4	2.36
Wonder	52	24	24	0	2.28
Respect	52	28	16	4	2.28
Cooperation	32	44	16	4	2.00
Love	32	28	28	12	1.80
Care	28	32	20	16	1.68
Humility	24	40	16	20	1.68
Unity	28	24	32	16	1.64
Relatedness	4	24	32	32	.92
Reverence	0	24	44	28	.92

Second Questionnaire

A compilation of comments by all scientists in the first questionnaire were part of the feedback sent to all scientists with the second questionnaire. Also included in the feedback were a summary table of combined group percentage ratings of all scientists on each of fifteen values and each scientist's individual ratings, sent only to the individual scientist (see Appendix B).

In response to the second questionnaire, ten scientists made a total of nineteen changes in ratings, all toward the group mean score. The changes as a whole made no significant difference in the combined ratings or rankings of the group.

Third Questionnaire

Responding to the third questionnaire, eight scientists who had one or more ratings outside the inter-quartile range of the group median changed their responses to nineteen ratings of ten different values. All but two changes were made toward the median. Fifteen scientists, who also had one or more changes outside the inter-quartile range of the group median, retained their previous ratings and provided reasons for thinking the rating should be that much lower or higher than the majority judgment of the group. As a result of responses to the third questionnaire, ranking of values, based on mean scores of ratings, shifted slightly as shown in Table 2.

Table 2

Comparison of Values Ranking from First to Third Questionnaires

Previous Ranking of Values	New Ranking of Values
Curiosity	Receptivity
Receptivity	Curiosity
Responsibility	Responsibility/Imagination
Imagination/Intuition	Intuition
Interdependence	Wonder
Wonder/Respect	Interdependence/Respect
Cooperation	Cooperation
Love	Care
Care/Humility	Love
Unity	Unity
Relatedness/Reverence	Humility
	Relatedness
	Reverence

Analysis of Scientists' Responses

Interesting Isomorphic Chains

Comparisons of scientists' comments revealed pairings or patterns of values that I call "isomorphic chains" of relationship between and among certain values. These pairings or patterns are isomorphic in the sense that certain values are alike on a fundamental level, but different one from the other in ways that make each value unique. Speaking in biological terms, isomorphic organisms might be the same or similar in form, but distinguished by attributes or details, perhaps on a microscopic scale. In chemical terms, when two molecules are exactly alike in the number and kinds of atoms they contain, but different in the way the atoms are joined together, they are said to be isomers, from the Greek, a term similar to isomorphic and meaning "of like parts" (Gardner, 1979, p. 106). The entities may differ in specific gravity, boiling point, and all sorts of other significant properties but still share an identical fundamental property--form or essence--called a "grandmother cell" by one scientist (Hofstadter, 1979, p. 344). To illustrate isomorphism, I offer visual representations by M. C. Escher (Figures 1 and 2). There is something fundamentally invariant about the butterflies in Figure 1, but the uniqueness of each butterfly is evident, as is the sameness of each. The isomorphism may be coarse-grained as in the butterfly illustration (Figure 1), or fine-grained as in the fish and bird illustration where each fish and bird share a subtle sameness (Figure 2), and each reveals unique differences effected by tessellations through the isomorphic chain.

Figure 1.

Butterflies by M. C. Escher

Source: M. C. Escher, (J. E. Brigham, Trans.), The Graphic Work of M. C. Escher, (New York: Ballantine Books, Inc., 1971).

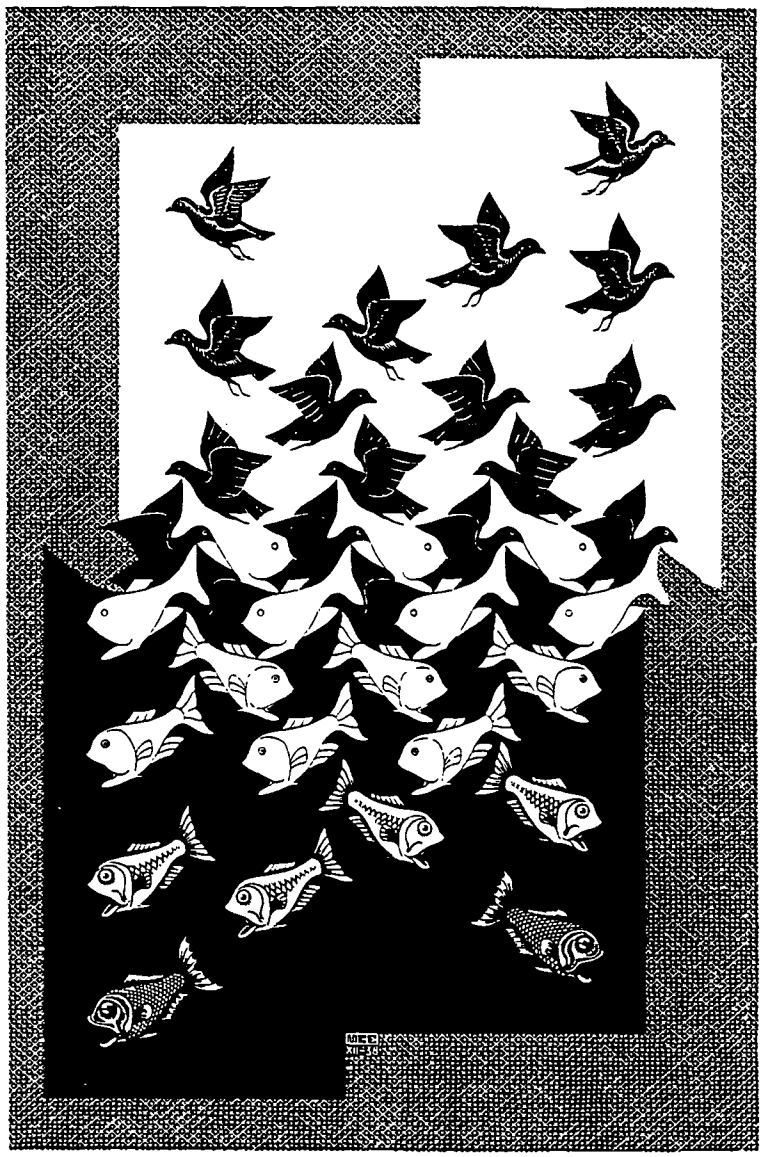

Figure 2.

Sky and Water II by M. C. Escher

Source: M. C. Escher, (J. E. Brigham, Trans.), The Graphic Work of M. C. Escher, (New York: Ballantine Books, Inc., 1971).

Each of the following isomorphic chains of values are related in a fundamental way; they have in common a "grandmother cell" of one sort or another--some invariant, inherent nature or meaning.

Chain 1: Respect.....→.....Reverence

Chain 2: Love.....→.....Relatedness

Chain 3: Interdependence.....→.....Unity

Chain 4: Curiosity.....→.....Wonder

Chain 5: Responsibility..→..Cooperation..→..Care

Chain 6: Intuition.....↔.....Imagination

Even though the values in each of the isomorphic chains above share a fundamental sameness or essence, scientists' responded to the subtle differences among the values in Chains 1-5 by supporting more strongly one value over another within a chain. For some scientists, a value may have gone one tessellation too far, rendering it so changed that the scientists were no longer able to support it. Figures 3 through 8 illustrate the differing degrees of support using words of scientists in the study.

Respect: Predominantly Supported	→	**Reverence: Predominantly Not Supported**
Lack of it has created immense environmental problems; a must for every form of life; failure to respect creates ecological and personal problems; abuses result in lack of credibility; wonder and curiosity lead to respect; we are but a tiny piece of the puzzle; why society has set aside national parks; the more I study nature the greater my respect; related to time spent in nature; should be reflected in scientific community; an important value for any career; children need it; true for me; most with whom I associate have it.		Can inhibit experimentation; getting pretty deep; spiritual connection is reasonably fuzzy; does not remain constant; goes against set scientific dogma; generally the feeling is that phenomena can be understood at a satisfactory level; I am not a spiritual person; I do not approach science with this; gives a negative bias; many successful scientists are agnostics/atheists; can block/misdirect work; too strong an emotion; not necessary to do science; doesn't fit into science; not testable; not necessary or desired.

Figure 3

Chain 1--Scientists' Comments on Values:
Isomorphic Chains Illustrated

Love: Predominantly Supported	→	**Relatedness: Predominantly Not Supported**
Essential to overcome obstacles; those who do not love their work produce little; see Aldo Leopold; must love your work to stay in it; without passion, why do it?; should apply to every profession!; my greatest gift; desirable; passion for science is positive; lessens tendency toward destructive research; love of nature comes from my leisure time; crucial; a personal driver.		No!; can invalidate a study; can't identify with practice of minutiae; seems impossible; not integral to studies at subatomic or molecular levels; obscures/destroys objectivity; I feel none for algae or insects; may be important for primate study; feel no rapport with many things I study; how an individual relates is not that important; personal involvement is a detriment; rapport can lead to bias; a hindrance; not at all important as I see it.

Figure 4

Chain 2--Scientists' Comments on Values:
Isomorphic Chains Illustrated

Interdependence: Predominantly Supported	→	Unity: Supported Less Than Interdependence
Grasp of this allows incredible advances; important; a key factor for ecologists; every electron in the universe is related as is each form of life on earth; everything is connected!; key aspect to understand impacts; important for society to be aware; failure to acknowledge leads to "solutions" worse than the problems; most studies require it; knowledge of one part can often apply to other parts; one must know this to grasp whole concept; comes from experience; on some deep level, all is connected; important to understanding cause and effect.		Not a fruitful approach in present society; not relevant to one studying synthetic materials; not so important; information explosion precludes holistic thought processes; bench scientists don't have this luxury; science is not necessarily harmonious; may be fine as philosophical belief, but not good for scientist in research situation; a scientist must focus more.

Figure 5

Chain 3--Scientists' Comments on Values:
Isomorphic Chains Illustrated

Curiosity: Predominantly Supported	→	Wonder: Supported Less Than Curiosity
Main Driving force; prime motivation; crucial; the spark of science; excitement in learning new is essential; drives the need to know; tremendously important; sustains one when the going gets tough; cannot discover without curiosity; makes you pay attention to things observed; without it answers won't come; has revealed a great deal to me; most scientists I respect are curious; a "true" scientist has an insatiable curiosity; most young people have it.		Very helpful in sustaining research; a motivator; one of the most important qualities; nature never ceases to amaze me. ..... Can cause more spectating than doing; need to a degree but without discipline and control, can impair ability to focus; only gets you part way as a scientist; a rare experience which is not important for a scientist; never felt wonder for mathematics or physical sciences.

Figure 6

Chain 4--Scientists' Comments on Values:
Isomorphic Chains Illustrated

Responsibility: Supported More Than Cooperation →	**Cooperation: Supported Less Than Responsibility, More Than Care** →	**Care: Supported Less Than Cooperation**
Need to be responsible for consequences of research or lack of research in critical areas; current-day imperative; should top our list; must do "down-board" thinking; research for research's sake unacceptable; must bear responsibility for results; incorporate into research design; ramifications must be thought through; essential; public demands it; especially important for the natural environment. ..... Most feel helpless to do it; simply not the way it works; can't be moral gatekeepers; almost impossible to do; not always a serious commitment related to the planet; hopeful, but not pragmatic; results depend on society as a whole.	Absolutely necessary; very important; opens immense possibilities; essential to developing; a must; must align around shared visions; necessary to discovering things outside our own preconceptions; only way work gets done; needed to achieve something great; ..... Some work best alone; one can succeed in lone endeavor; a lot of good science has been done by loners; doubt that many bench scientists give thought to "harmony" for survival.	Essential; vital to research; without it science can't be done effectively; the hard part of doing science; required; especially difficult in world of instant gratification; heightens number awareness; patience is the key. ..... A nice bonus; is expendable; does not apply to chemist; impossible in some aspects of science; may impede progress; has little to do with pragmatic science.

Figure 7

Chain 5--Scientists' Comments on Values:
Isomorphic Chains Illustrated

The disparity among the values in the isomorphic chains was validated by the relative positions of the values in the scientists' rank order of all values (See Table 1). Relative positions are shown below with rank order placement noted in parentheses and one (1) being of highest value.

Respect (6-7).....→.....Reverence (14-15)

Love (10).....→.....Relatedness (14-15)

Interdependence (6).→.....Unity (13)

Curiosity (1).....→.....Wonder (7-8)

Responsibility (3)..→..Cooperation (9)→..Care (11-12)

Only "imagination" and "intuition" held the same position (4 and 5) in the ranking of values--which is, as are the disparities among other rankings, evident when comparing comments by scientists on the two values (see Figure 8).

Imagination: Supported Similarly to Intuition	↔	**Intuition: Supported Similarly to Imagination**
Very important; essential for truly excellent science; greatest strides made by those having it; the cutting edge; separates leaders from followers, scientists from technicians; creative minds require it; ability to see what is possible, not merely probable; source of vision. ..... Must be controlled by understanding; knowledge and deductive reasoning more important than imagination.		Very important; essential; cuts the "pros" from the amateurs; provides a means for the next step; follow informed hunches; makes a great scientist, but an eccentric one!; creative scientists have it; powerful. ..... Follows from analysis rather than a "guess"; it works . . . sometimes; many times leads to dead ends; a lot of science is focus and grind; must be balanced; relaxed playful minds aren't likely to generate grant money.

Figure 8

Chain 6--Scientists' Comments on Values:
Isomorphic Chains Illustrated

Resonance Between Scientists and Nature Writers

The third round of questionnaires resulted in a shift in ranking of values as shown earlier in Table 2. The shift in ranking related to a change in the mean score of thirteen of the fifteen values. Of those changes, all but two were in the direction of a higher degree of support for the value as one essential to the work of a scientist and, therefore, to the science education of young people. Therefore, the process of iterative response and feedback of the Delphi questionnaire brought the scientists' ratings of values into greater resonance with the values held by the Nature Writers, from whose writing this list of values was originally drawn. Generally, the higher the scientists' ranking of a value, the greater the resonance with Nature Writers.

Greatest Dissonance Between Scientists and Nature Writers

Two of the values--relatedness and reverence--illustrate the greatest dissonance between values held by scientists and values held by Nature Writers. A summary of scientists' comments on these two values is included in Figures 3 and 4. Notable, however, is that most of the scientists' stories of experiences with nature (to be described in the next section of this chapter) reveal personal relatedness and involvement with the subjects and the process of their research or with the natural world. Notable also is that eleven of the scientists' stories include an element of spirituality, awe, and reverence, even though the value of reverence was generally not considered essential by scientists in their rating of values. It appears the scientists' actual experiences with nature belie their

considered ratings of the values of relatedness and reverence. This result, among others, will be presented in Chapter 6.

Possible Misinterpretation of Values Statement

Comments by scientists revealed that the relatively low rating and ranking of the value of "humility" most likely resulted from misinterpretation of words used in the values statement. Six of eleven scientists who rated humility as not important did so on the basis of the following offending phrase in the statement: "does not make assumptions based on partial knowledge." Comments by the six scientists included the following:

- Since we only ever have partial knowledge, and must make some assumptions, this statement seems unsupportable to me.
- You sometimes must make assumptions based on partial knowledge to continue your line of inquiry.
- All assumptions that lead to discoveries are based on partial knowledge.
- We rarely have all the knowledge needed to make the best assumptions; assumptions on partial data is what allows us to make and test hypotheses.

It appears that the offending phrase "make assumptions" was misleading in the original questionnaire. The intent of the values statement of humility was to convey the meaning that scientists would be humble enough to draw conclusions only on the basis of strength of data. If the offending phrase ("make assumptions") were removed or replaced by "draw conclusions," it appears the statement would have been supported by six additional scientists.

The five scientists who remained unable to support humility as an essential or even acceptable value for a scientist did so mainly on the basis of the place of humility in the scientific enterprise. Conveyed by their comments was the sense that a scientist must "fend off bullies," "beat one's drum incessantly," "not bow to authority," and be "very aggressive" and "self assured" to survive in the scientific enterprise. It seems evident that "humility" was not considered by these five scientists in the context of the study of nature or the constituents of nature, but as an attribute of a scientist making his or her way in the social-political or economic arena, struggling to gain support for conducting scientific research.

The remaining fourteen scientists supported the importance of the value of humility in the context and meaning in which it was intended and included as a value in this study. Comments included the following:

- Humility is absolutely essential.
- The ever present possibility that we may not really have our concepts right, or that we may make mistakes, should always temper our methods.
- The scientist needs to know that he/she is not bigger than the science.
- We do not know everything, nor is there an unwritten law that says we must.
- In science we can never prove something to be true, only prove that a particular thing is not true for a certain way of doing it.

In conclusion, it appears that, but for the misinterpretations noted, the scientists would have rated the value of humility higher than they did and that, consequently, that

value would have assumed a relatively higher position in the ranking of values by the scientists.

Presentation and Analysis of Scientists' Stories

The second part of the first questionnaire sought insight into how scientists relate to the natural world or to the constituent parts of nature that receive their attention and focus. The three-part question is included in Appendix A.

Twenty-three scientists recounted or summarized direct experiences with nature, and also stated the importance of the experience to their understanding of the natural world and to their development as scientists.

As part of the feedback for the second questionnaire, each scientist received a copy of her or his "story" and was invited to elaborate and revise, as desired. Ten scientists elaborated or revised their stories or added comments, including major new reflections and minor changes to clarify meaning.

Analysis of the scientists' stories included a process of segmenting data that represented elements of scientists' reported relationship with nature, developing coding categories or story elements, sorting and re-sorting segments within categories, and generating patterns or themes. What emerged was a typology of story elements as defined in Table 3.

Table 3

Typology of Story Elements Based on Scientists' Responses

1. Negative "Fear it"	Fear, aversion, alienation from nature
2. Utilitarian "Use it"	Practical and material exploitation of nature
3. Dominionistic "Control it"	Mastery, physical control, dominance of nature
4. Natural "Explore it"	Direct experience, discovery and exploration of nature
5. Scientific "Know it"	Systematic study of physical/mechanical structure and function of constituent elements of nature at the fundamental unit level, e.g., organ or cell
6. Ecological "Understand it"	Systematic study of physical function, process, and relationships among elements of nature at the level of whole organisms and ecosystems, i.e., the web of life
7. Aesthetic "Appreciate it"	Physical appeal and beauty of nature
8. Humanistic "Love it"	Strong emotional attachment, and "love" for aspects of nature
9. Moralistic "Care for it"	Ethical concern, moral commitment, and feelings of altruism and responsibility for nature
10. Spiritual "Merge with it"	Reverence, a sense of sacredness, harmony, oneness, joy, ecstasy, or feelings of desire for mystical union with nature

Labels for categories of story elements were suggested by several sources who discussed in their writings the human relationship to the natural world (Kellert, 1996;

Kellert & Wilson, 1993; Reed & Slaymaker, 1993; Worster, 1977). Though the labels for the typology of story elements for this study most resemble those described by Kellert (1996), significant differences exist. Kellert included no category for the "spiritual" story elements that emerged from the scientists in this study, nor did he make a clear distinction between two categories of knowledge-based experiences in science that emerged from the scientists in this study, which I have labeled "scientific", in one case, and "ecological", in the other. Omitted entirely from the typology for this study was a category Kellert labeled "symbolic."

All but two of the scientists' stories had more than one element. Overall, eighty-five story elements emerged, as shown in Figure 9.

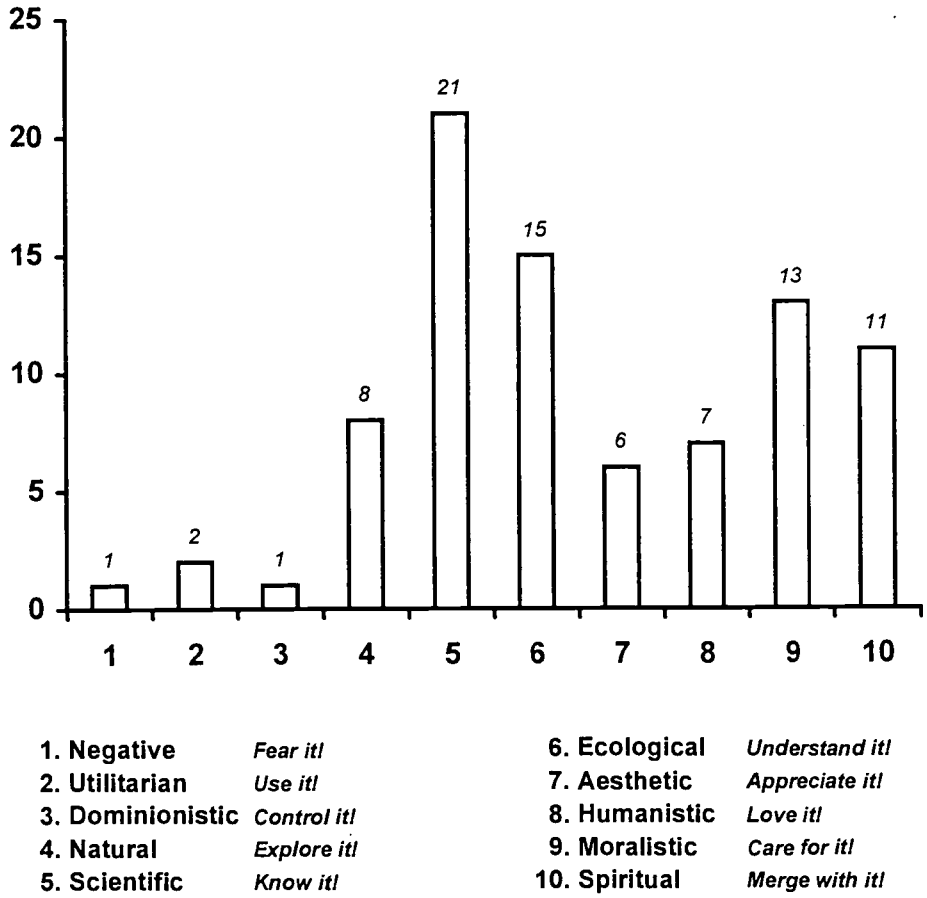

Figure 9

Story Elements--Scientists

Summary of Story Elements

Following is a summary of story elements, in the words of the scientists, where possible.

1. Negative: One scientist described a relationship with nature that included fear, aversion, and alienation from nature. The scientist felt "frightened," and "truly alone in

the cosmos." but "thrilled to be alive" though having "no real sense of the big picture." He said: "I do not have a clue."

2. Utilitarian: Two scientists described practical and material exploitation of nature for food, medicine, clothing, tools, and other products. One noted that he works to "increase the use of renewable energy by mankind;" the other spoke of living off the land and "harvesting what is needed for sustenance."

3. Dominionistic: One scientist described a relationship with nature involving mastery, physical control, and dominance of nature. He spoke of "mastering" what was needed to meet the "challenge of surviving" in the natural world.

4. Natural: Eight scientists described direct experience of discovery and exploration of nature that brought "extreme joy and satisfaction," was "therapeutic," "fascinating," and "a diversion." The "amazing detail" of nature was described as "filling one with excitement, curiosity and joy"; it was "both exhilarating and relaxing" and stimulated a "long-standing curiosity" and "sense of wonder." Several described a childhood filled with "innocent curiosity," "fascination," or "amazement," sometimes "camping in the wild, outside with the sun and wind in my face." Selected additional descriptions follow:

- Nothing has given me more personal pleasure than the mystery and challenge of the natural world.
- To my surprise and wonderment... extraordinary life continues even under the harshest conditions.
- It is only in the close presence of the natural world that I feel truly at ease.

5. Scientific: Twenty-one scientists described a relationship with nature that involved systematic study of physical/mechanical structure and function of constituent elements of nature at the fundamental unit level, e.g., organ or cell. Described is the desire to "explore new worlds," "probe and investigate," "acquire knowledge," or confirm that the natural world is to "some extent predictable" and able to be understood. Making a "breakthrough" or a "new discovery" was often part of the described experience, accompanied by "personal satisfaction," even "joy," and sense of intellectual accomplishment that may lead to a "life devoted to pursuing truth, through science." Some stated that it was an "objective" experience, unaccompanied by any "profound" or "emotional" content. Some associated the satisfaction with the "certainty" that is derived from science and stated that "such new understanding makes the world more difficult or complex as well as simpler and more understandable."

An intensity was evident, a "zest for knowledge," a "challenge to explore my enormous capabilities and learn more about our limitations," and a desire to "master concepts in a given field." Others described "knowledge" as the "quintessential requirement of a scientist," along with "sound reasoning," "logic" and "expertise" that prepares one to contribute to solving "one small part of the puzzle." One scientist stated,

> Questions of how and why living things are the way they are focused my interest on the brain and learning and how our brains organize our interactions with the world and how the world around us shapes and organizes our brains.

6. Ecological: Fifteen scientists described a relationship with nature that involved systematic study of physical function, process, and relationships among elements of

nature at the level of whole organisms and ecosystems, i.e., the web of life. Described were experiences that "grounded previous beliefs and understandings"; helped to "sift and sort" thoughts and learn that "all things are related on some basic level and in an essential way." These understandings led to the conclusion that "preserving our planet and exploring new worlds will require a knowledge of history, anthropology, psychology, and other fields"--and "a global effort."

Described were studies that reveal "the inter-connectedness of all life and its intimate relationships to its environment"; studies that "help me keep the big picture in mind and see the relationship of the pieces." Example illustrations include observing a field mouse using an abandoned cactus wren nest; watching a Great Horned Owl kill a Striped skunk; examining effects of metal contamination in biota and sediments along the river and thereby understanding pollutant transport; and viewing "the planetary ecosystem as an organism of which we are all a part."

Experiences were described that brought awareness of interrelationships between the scientists and species: "our inner self and beliefs are completely embedded in our perceptions of species, individuals and ecological interaction." One concluded that "we humans are animals as are many creatures on earth." Another "recognized relationships that run through different disciplines" and was better "able to grasp and apply subjects such as quantum mechanics" and became "very comfortable with paradoxes." One said, I saw "evolution at work, a truly progressive evolution." Additional descriptions follow:

- To maintain trout requires knowledge of entire watersheds.
- The cumulative effects of what I do or don't do on a daily basis have, over my lifetime, a profound effect on everything whether proximal or distal to me. The same applies to everyone. Some are merely more sensitive to this impact than others.
- My mother . . . shaped my view of the world. All things had an important role, the winds, the rain, the sky, everything . . . worms worked the soil
- . . . ants cleaned the earth . . . every creature depended on the next in the web of life . . . creatures in turn depended on the earth.

7. Aesthetic: Six scientists described the physical appeal and beauty of nature, including appreciation for the fascinating variety and complexity of the natural world and wonder at the stars. One said "I have tremendous feelings of appreciation and awe when I view the magnificence of nature and natural beauty." Another's appreciation for the natural world was increased while looking at the vast universe and thinking of earth as "a giant rock hurling through . . . space." Another captured the beauty by photographing nature. An appreciation was engendered for one by the "amazing detail," "variety and complexity" of nature. Additional descriptions include the following:

- My appreciation for nature runs deep.
- The ocean was a dark abyss, lit up with millions of sparkling dynoflegellets. All life forms were approachable and glowing in their beauty.

8. Humanistic: Seven scientists expressed a strong emotional attachment and love for aspects of nature. These "strong positive feelings for the natural world" were evident

particularly in bonded relationships with creatures, including a "passionate experience in the aquatic realm," looking into the eyes of a giant octopus whose huge eyes were also observing him; and as a child, "staring deep into the limpid brown eyes of a Great White Pyrenees." Described also was an attachment so close that the scientist experienced "taking the illness" of a cherished pet; and another calmed by gentle talk a terrorized porcupine in the wild.

Several identified intimately with wild creatures, coming to "understand the innumerable marvelous adaptations that both we and these animals have made to accomplish our very similar needs." Experiences so "organic" were described that "the aliveness of even the masses of green algae" was felt and "passion, love, and attachment" were engendered. Other descriptions include the following:

- As long as I can remember I have loved . . . nature and nature's creatures.
- My strong attachment, passion, joy are a core element in my personality.
- There are passionate moments in science that just keep you motivated.
- I have loved walking in streams as along as I can remember.
- Caring for animals was central to me; friends and neighbors routinely deposited the odd injured bird, out-of-nest infant squirrel, etc. with me. Reptiles became a particular passion. . . . My delight at finding a gopher tortoise led to uncountable hours of intense involvement with this tribe of gentle creatures . . . spent years caring for boas and pythons.

9. Moralistic: Thirteen scientists expressed ethical concern, moral commitment, and feelings of altruism and responsibility for nature. Described was "the need for great respect and care of all things organic or inorganic," and "an overpowering sense of respect for everything in nature." Many said they were "driven by a moral concern for the survival of the world," "appalled" by the destruction and over exploitation of nature and "disgusted" by "carelessness" and by those who "willingly destroy wildness." Called for was the need to "act in a more environmentally acceptable manner," "develop tools others can use," and "help others exercise their desire to live more justly upon the planet."

Described were experiences with nature that caused personal moral transformation. A "happy-to-be-alive philosophy" was magnified for one scientist. For another, the experience in nature inspired a "hope" that "my contribution will help future generations," a "persistence in the face of adversity," and a feeling that there is really no "difference between a human's soul and any other vertebrate."

Recognized were the potential healing benefits of scientific work and a sense of urgency to act, illustrated by the following: "Scientific research can recognize pitfalls in advance," "somebody has to find those technologies, carry out those experiments!" and "science . . . is about service to humankind and the environment." About scientists, this was said: "Theirs is a calling to service," "to make real, substantive contributions" and "leave the world a better place." Other descriptions follow:

- From childhood, I wanted to help preserve plants and animals and environments for future generations and for future study.

- We do not need to kill other life forms in order to understand them.
- Uncovering better forms of construction for housing the world in a more sustainable manner, I am contributing one small piece of the puzzle to allow man to continue inhabiting the earth in a more harmonious manner.
- Motivation to help people in the long-term has been the main factor in my development as a scientist.
- The more time I spend with nature, the better I feel as a person.
- Can the scientist be also the Shaman? If not, there is no hope for us.

10. Spiritual: Eleven scientists described experiences that brought reverence, a sense of sacredness, harmony, oneness, joy, ecstasy, or feelings of desire for mystical union with nature. These experiences "validated my belief in God," "helped me keep the big picture in mind," "tapped sources outside "normal" human networks." or moved the "boundary of my knowledge to a more inclusive position." Included were descriptions of a "spiritual," "very transcendental experience" being "one with the aquatic realm" during a high dive while working at a marine biology research station as a student; "spiritual experience" when "fly fishing for trout," and experiences in "both laboratory and field work."

The result was a "sense of oneness with nature" or "unity"; a feeling of "being a small part of the wholeness"; and thoughts that "we live in a dynamic field of possibility." The impact of uncovering new truth was sometimes described as spiritual: "I feel . . . God has revealed one of her secrets to me." The impact, for some, is enduring: The "realization that I had new knowledge . . . led to a sense of oneness with nature . . .

and all the work I have done since that time [26 years ago] has been applications of this concept."

A series of spiritual experiences in nature is occurring for one scientist who described "a process I don't really understand . . . of exploring different realities." One incident is described below:

> Once, driving back from a visit with Fawn JourneyHawk, a social worker, Native American called to a medicine path, I resolved to abandon all these "psychological" matters. At that instant, a nighthawk dove out of the blackness and exploded against my windshield. Shaken, I continued home. During the night another nighthawk flew into the front door of my house and died. Was that a message? You bet your wooly socks it was--unless you decide it was not.

The impact of these experiences is that this scientist now "sees the web more clearly" and knows that "transformation is not an incremental process--sometimes we must kill our past." Included also were the following descriptions:

- Camping . . . waking to the bird song, with the morning cool breeze, and beginnings of sun warmth around and upon me, I could feel a connectedness, a feeling of spirituality that ran not just around me, but also through me.

- I have felt that I and other living elements have always existed, we are eternal entities. There is a flow of intelligence from another sphere."

- Sitting under a mountain ash tree . . . staring up at the cottonwood leaves, often I would feel inseparable from the leaves and trees--entering into a kind of meditative trance . . . I frequently felt the aliveness of trees.

Importance to Scientists of Experience with Nature

Scientists described the importance of the experiences with nature to their understanding of the natural world and to their development as scientists. The distinction between effects of the experience that were important to "understanding of the natural world" (Question B) and effects important to "development as a scientist" (Question C) was not clear. The same or similar categories emerged from scientists' responses to both questions. Scientists' responses overlapped the categories and blurred the boundaries considerably across both questions, and justifiably so, in my opinion. It is difficult to conceive of an effect important to understanding the natural world not also being important to development as a scientist, and vice versa. I was unable to anticipate this possible response. Therefore, responses presented in Table 4 represent a composite of both questions. Noted for each category of response are the number of scientists whose response fell in that category. If a category appeared in a scientist's answers to both questions, it was reported only one time. Responses of many scientists fell into more than one category.

According to the scientists' responses to the questions, their reported experiences in the natural world affected them in the following ways:

Table 4

Effect on Scientists of Their Experiences with Nature

Effect/Importance of Experience	Number of Scientists
Motivated, challenged, stimulated, and inspired persistence.	7
Inspired optimism/confidence that I can make a contribution.	7
Deepened my understanding (especially of ecology); grounded my knowledge.	6
Affected the sum total of my values or world view.	6
Increased my sense of care/responsibility for people and the planet.	5
Directed or guided my work/career thereafter.	3
Increased my appreciation/awe of nature.	3
Revealed a spiritual consciousness/ connection to nature.	2
Uncovered new knowledge that advanced science.	1
Not much effect.	1

Scientists' "Non"-Stories

Two scientists chose not to write stories of their experience but rather wrote rebuttals to the question itself, challenging the validity of asking scientists to describe

experiences perceived to them to be not objective or scientifically testable. As part of the analysis, I noted that an inordinate number of the negative comments on the values ratings could be attributed to the scientists who wrote the "non"-stories. This correlation is shown in Figures 10 and 11.

Scientist A: "Non"-Story	Scientist A: Non-supportive Comments on Values
I cannot recall such experience as you have outlined. The terms you have used in this question . . . set things in a somewhat metaphysical or religious environment. While many emotions are good attributes in science, other may be bad. To see a religious fulfillment in science is a bad or weak basis for pursuing so difficult a career. I and most scientists I know as friends separate the areas of the spiritual and metaphysical from science and the physical world. In general, science and scientific method establish a guide to explaining phenomena that is rigorous. To invoke metaphysics or the supernatural to explain something generally gives an explanation that lacks knowledge.	Wonder: Without discipline/control, can impair ability to focus. Reverence: Too strong an emotion; can block or misdirect work. Humility: Not a good virtue; must have strong confidence in your own ability. Relatedness: How one relates not that important; can destroy objectivity. Interdependence: Can cause one to lose focus. Unity: not necessarily good for scientist; must focus more. Responsibility: Almost impossible to do; Hohn, who discovered fission, could not have foreseen Hiroshima. Imagination: Must be controlled by understanding.

Figure 10

Scientist A: Comments on Values Correlated with "Non"-Story

Scientist B: "Non"-Story	Scientist B: Non-supportive Comments on Values
My idealism and love for the natural world have little to do with my survival in today's science. Nowhere do you even mention the quintessential requirement, which is knowledge, and the mastering of concepts in a given field. Survival in science requires total dedication, perseverance, bullheadedness--ability to communicate thoughts clearly, concisely, precisely. In today's marketplace environment, survivors must be highly competitive, articulate. While values and spirituality may be very important qualities in living--funding of grants in molecular biology are predicated on knowledge, sound reasoning, logic, relevancy, etc. . . ., not on one's spiritual being.	Wonder: Never felt it for mathematics or physical sciences. Respect: Much science does not demand it. Reverence: I am not a spiritual person. Humility: Survival in science demands self-assuredness. Love: Does not come from my work. Relatedness: Can't identify with the practice of minutiae. Interdependence: No longer study organisms so doesn't apply to study of molecules. Unity: Information explosion precludes holistic thought processes. Bench scientists no longer have the luxury of contemplating "kinship." Care: Has little to do with pragmatic bench science. Cooperation: Doubt that many scientists give much thought to "harmony." Responsibility: Not a pragmatic objective. Imagination: Knowledge and deductive reasoning more important than imagination. Intuition: Relaxed, playful minds aren't likely to generate grant money.

Figure 11

Scientist B: Comments on Values Correlated with "Non"-Story

Gender and Racial/Ethnic Group Comparisons

Although the numbers were low of women scientists and those from other than the dominant racial/ethnic group participating in Stage Two of this study, the numbers represent the approximate ratio of women to men and a slight over-representation of racial/ethnic ratio of diversity. Based on prior knowledge of responses from women scientists in particular, and also based on what I perceive to be the "feminine" quality

inherent in many if not most of the values derived from the Nature Writers, I had expected to observe significant gender or racial/ethic differences among the ratings, comments, or stories of the scientists. I compared ratings at every level of rating and at combined ratings of more than one level and also compared comments and stories across gender and racial/ethic differences. I conclude that no significant gender or racial/ethnic differences were found among the ratings, comments, or stories. However, that information alone may be significant in regard to women scientists for the results indicate that traditional "feminine" qualities ascribed most often to women are no more evident in women scientists than in men scientists.

Summary

Nature Writers and scientists each have a particularly intimate relationship to the natural world and, therefore, bring a rich and deep ethos to the study. Nature Writers tell of their experiences immersed in the natural world as participant-observers of nature. Scientists tell of their experiences working up close with nature and the constituents of nature in field or laboratory setting. This chapter presented results of the data collected and analysis of scientists' values and views in relation to those of the Nature Writers. Together these values and views lead to findings, presented in Chapter 6, that point toward an essential ethic for teaching science.

CHAPTER 6

Discussion

The purpose of this study was to identify and explore values and views that might underlie an essential ethic for teaching science in the new millennium. With such an ethic, teachers may be better able to prepare young people to form and fully participate in communities that restore and sustain Earth. Important to achieving this vision is an understanding of the values and views that make up our knowledge of the nature of nature, the value of nature, and the human relationship with nature. Once seen and known, however, an ethic of lived-out values remains the conscious choice and commitment of individuals and communities in the here and now: "An ethic with its owner is lived as biography, a story line on location in historical time and geographical space" (Marietta, 1995, p. xi).

Historical literature tells how humans from antiquity to the present time have lived out their values in relation to the rest of the natural world. The human perception of the nature of nature and the value of nature has varied over time, influenced by philosophical, religious, and political teachings, beliefs, expediencies, and exigencies. Nature has been valued varyingly as a resource and a source. The more-than-human world of beings, life forms and systems has been considered, alternately, inert, expendable and separate from humans; vital, alive and part of the human spirit; friend and foe; evil and beloved. What has not vanished, but perhaps has withered, is biophilia, the natural innate affiliation of humans--fearful or loving--with the rest of the natural world

(Wilson, 1984). Indifference or neutrality in the human relationship with nature is a myth. The belief that the practice or teaching of science is values-free is also a myth. A preponderance of evidence exists that a values-based world view suffuses both science and science education (Proper et al., 1988; Ramsey, 1992). Given ecological and community degradation and fragmentation, the question to be answered is: What values in relation to the natural world must be instilled in young people so that they may live to restore and sustain the Earth?

Findings

To explore values that might underlie an essential ethic for teaching science, this study brought forth the values and views of two groups of participants--Nature Writers and scientists--who have in common an uncommon intimacy with the natural world. The two groups stand in also as representatives of what many see as two distinct cultures--science and humanities--often viewed as opposites, but whose perceived opposition may be a reflection of that time-honored Cartesian bifurcation between the world of matter and the world of mind, heart, and spirit.

Although the context for relating to the natural world is different for each of the two groups of participants, the impulse of attentiveness to and appreciation of nature is at the heart of each and is the rationale that binds the two groups together for this study.

Findings are discussed below in the context of the questions that guided the research process.

1. What values and views are held by those most intimate with the natural world, among them Nature Writers and scientists?

Earth-care values--manifest in cognitive, belief, and emotional domains--were found to be held in common by the Nature Writers and scientists in this study. Values manifest as spiritual were found to be embraced by the Nature Writers and some of the scientists, but held at arm's distance by other scientists in this study.

Nature Writers were asked first, using their writing as a source, to reveal either explicitly or implicitly the essential values they hold in their relationship with the Earth. Fifteen dominant values emerged, among them, not surprisingly, were many strong Earth-care values including receptivity, responsibility, interdependence, respect, cooperation, love, care, humility, unity, relatedness, and reverence. Also included were curiosity, wonder, imagination, and intuition. Complete values statements can be found in Appendix C.

The first questionnaire sent to scientists asked the following question about the fifteen values drawn from the Nature Writers: How important do you believe these values are to your work as a scientist and, therefore, to the science education of young people? Scientists strongly validated two of the values--receptivity and curiosity--as "essential-must be included." Others were validated to varying degrees as "essential" or "important" with the exception of relatedness and reverence. The greatest percentage of scientists rated the two values--relatedness and reverence--as "nice, but not necessary" or "not at all important, no need to be included." There were strong exceptions, however, and scientists taking exception refused to relinquish their support of the values of relatedness or reverence through several iterations of questionnaires.

Comments by the scientists about each of the values validated their ratings. Although the group of scientists as a whole did not support the values to the degree that was evident among the Nature Writers as a whole, many values were found to be held in common by the two groups. The strongest dissonance between the Nature Writers and the scientists was evident in the scientists' low rating and non-supportive comments on the values of relatedness and reverence, as noted earlier, even though scientists supported the two values of love and respect--similar in quality but, on a continuum, not so intense.

2. What values, themes, and perspectives emerge from the voices of Nature Writers and scientists--on the nature of nature, the value of nature, and the human relationship with nature? Is there a resonance or dissonance between the Nature Writers and the scientists?

Nature Writers were found to see nature as vital, alive and originary, and intrinsically valuable. From their view, nature encompasses humans who live in reciprocity--biogeochemically, emotionally, and spiritually--with the rest of the natural world. Scientists were found to agree or resonate with the perspectives of the Nature Writers to a great extent, even though some scientists were found to be reluctant to declare openly their strong emotional or spiritual affiliations with nature. Not surprisingly, scientists, more so than Nature Writers, were found to investigate and probe nature to yield answers to life's mysteries. Few scientists and no Nature Writers were found to maintain a traditional sense of nature as exclusively apart from and under the dominion of humans. Some Nature Writers, however, valued Nature most as a route through which they transcended their humanity and communed with a Being or Spirit

greater than all of nature. And some scientists saw the constituents of nature primarily as means for satisfying intellectual pursuits.

To explore answers to this question, scientists were asked by written questionnaire to describe their direct experiences with nature, if any, that they considered to be transcendent, relational or spiritual, or that brought them to a sense of oneness with nature or to profound ethical or moral concern or insight, strong attachment, passion, joy, or love. Scientists were also asked to describe the importance of the experiences to their understanding of the natural world and to their development as scientists.

Analysis of the scientists' stories revealed values and themes that fall into ten categories of story elements representing four general affiliations with nature: emotional (aesthetic, humanistic, negative); belief (moralistic, utilitarian, dominionistic); cognitive (ecological, scientific, natural); and spiritual. (Categories are defined on page 146.) Story elements depicting cognitive affiliation more than double the number of elements falling into either emotional or belief-based affiliations. Within the affiliations, however, only the categories of scientific (21) and ecological (15) exceed the number of story elements that fall into the categories of either moralistic (13) or spiritual (10). (Numbers in parentheses indicate number of story elements.) Contrary to what might have been expected from scientists based on theories represented in the literature review, few story elements could be categorized as negative (1), utilitarian (2), or dominionistic (1).

Although the setting was outside the work place for most of the stories that fall into an aesthetic, humanistic, moralistic, or spiritual category, scientists said that these

experiences affected their understanding of the natural world and their development as scientists. Scientists' stories in these categories also resonated with Nature Writers' descriptions of their relationships with nature. Two scientists chose not to write stories of their experiences, but rather wrote rebuttals to the question itself, challenging the validity of asking scientists to describe experiences perceived by them to be neither scientifically testable nor objective. These "non-stories" correlate strongly with negative comments by scientists on the values ratings and, therefore, support theories of scientists' world views found in the literature.

3. What values must be instilled in young people so they may be prepared to form and fully participate in communities that restore and sustain Earth?

Strong Earth-care values held in common by the Nature Writers and scientists in this study could be considered foundation values for an essential ethic for teaching science in the new millennium, toward which this study is aimed. Emotional and spiritual values held by the Nature Writers, but not validated strongly by scientists, should not be dismissed summarily but rather should be considered in light of the rationale for exclusion noted in the scientists' comments. They should also be considered in light of the historical happenstance noted in the literature that set the spin on the history and philosophy of science that excluded both emotion and spirit. Clearly, scientists in this study revealed in their stories that they harbor both emotional and spiritual values to a greater degree than might have been predicted by the literature.

Conclusions

Findings of this study suggest the following conclusions:

- Beauty, joy, drama, care, love, and passion are a part of the scientific enterprise.

Nature Writers and scientists--representing the humanities and sciences, respectively--are not so far apart in values as might have been predicted by trends in historical literature about scientific perceptions of nature, about values in science, or about the perceived distance between the literary and the scientific cultures. A degree of resonance exists between Nature Writers and scientists in this study on most of the fifteen values found dominant in the writing of the Nature Writers. Nature Writer and scientist Rachel Carson (1955) described it this way: "If there is poetry in my book about the sea, it is not because I deliberately put it there, but because no one could write truthfully about the sea and leave out the poetry" (Elder, 1985, p. 172).

- Those in the humanities may have a fuller, richer relationship with the natural world than those in the sciences.

In this study, the range of affiliation with nature was narrower for scientists than for Nature Writers. Values and views held by Nature Writers reveal a full range of affiliation with nature that is all of the following: emotional, aesthetic, belief-based, cognitive, and spiritual. Furthermore, Nature Writers readily came under the "Spell of the Sensuous," describing experiences of acute awareness of being drawn into sensory, even sensual, experiences with elements of the natural world (Abram, 1996). They brought the human body present in their encounters with nature. Language itself seems to be the expression as well as a catalyst for truly "being there." Adventurers and mystics among the Nature Writers, such as Annie Dillard, Edward Abbey, John Muir, and Terry

Tempest Williams, immersed themselves in nature, expanding their fields of personal response to nature. In their writing, they synthesized science and art in religious and spiritual terms. Scientists among the Nature Writers, such as Lewis Thomas, Loren Eiseley, Stephen Jay Gould, and Rachel Carson, expressed results of their research with the warmth and complexity of the emotion that flowed into their science.

- Scientists appear to be reluctant to declare themselves on emotional or spiritual values in science or in nature.

Results of scientists' rating of the Nature Writers' values revealed that, although scientists acknowledged the importance of love and respect, they were less likely to acknowledge the extension of those values into relatedness or reverence. Notable, however, is that the scientists' stories about their experiences in nature belie their ratings of these values. Nearly half of the scientists described experiences that had a spiritual element of reverence, transcendent awe, oneness or unity and more than half revealed in their stories an emotional attachment or connection to the natural world or deep appreciation for its physical appeal and beauty. Furthermore, the majority of scientists reported also that their experiences with nature profoundly affected their motivation and persistence in science and affected their values and world view.

Related to this conclusion, data suggest that scientists may feel compelled to leave part of who they are outside the door when entering and working in science. A number of scientists in this study who revealed a sense of beauty, joy, reverence, love, or passion for nature also stated that they received this sense only outside the scientific work place. The

content and tone of scientists' comments suggest that they may be conflicted about this discrepancy.

- Science education, more than science itself, retains more than a residue of the historical dualism between mind and matter, or spirit and body.

Despite the emergence of ecology and sciences of complexity, a dominance-model, utilitarian, mechanistic world view prevails in science textbooks, science teacher preparation, and science classroom dialogue. Science education itself appears to be the last to learn. Among scientists, many evidently have transcended their education as their careers and science have advanced, but others have not. Some scientists describe out-of-school childhood experiences of sensing complex interrelationships in the natural world which are not now evident in descriptions of their work as scientists. Some evidence from scientists' comments, however, indicates that the so-called "new" sciences of ecology, uncertainty, and complexity have begun to undermine the effects of an education in science that most likely was, and remains for most young people, suffused with philosophical dualism coupled with a mechanistic world view.

- Aesthetic appreciation, imagination, deep love and reverence for nature are compatible with quantitative intelligence and deep cognitive understanding of the natural world.

More than compatible, they appear to be synergistic. Nature Writers in this study do not divorce reason and science from affirmations of their aesthetic, ethical, emotional, and spiritual experiences in nature. In fact, the kind of intimacy afforded by scientific observations seems to enhance their appreciation, love, and reverence. According to

Nature Writer Terry Tempest Williams (1996), "Science is a tool by which we enter, see, and begin to articulate what the sacred is, what these natural relationships are" (p. 1).

Despite the views of two scientists in this study who consistently rejected any notion that the practice of science might include personal relationship with nature, most acknowledged the value to their research of imagination, intuition, receptivity, interdependence, care, and responsibility. Many also reconnected science with the immediate wholeness of the human experience of unity, mystery, love, and beauty. In their stories, nearly half of the scientists recognized spirit in the Earth and its creatures and expressed deep moral concern for the well-being of the planet. This study seems to suggest that the schism is narrowing between arts and humanities on the one hand and science on the other.

Implications for Practice

> How is it that we have strayed so far from that which feeds and elevates our souls? And how do we find our way back into the arms of wildness?
>
> (Williams, 1996, p. 2).

We have come to understand at least in part how it is that we have strayed; to find our way back, the following are practical implications of this study for educating young people in science:

- Teach the philosophy and history of science along with the science.

Teachers must come to know, so they may teach their students, the dramatic changes the human relationship to nature has undergone from early indigenous cultures to

the present. In short, to be truly science literate and prepared to act in ways that restore and sustain Earth, we must go through philosophy. Understanding the changing philosophies and theories of the nature of nature and the value of nature will help teachers convey to students how these perceptions have influenced the values that today underlie the work scientists do and the ways young people are educated in science. Teachers will be able to abandon dishonest and misleading pretensions to neutrality in regard to values in science. With this understanding, students will learn that science is not a straightforward matter of drawing conclusions from empirical observation but that it is actually a complex and puzzling partnership of theory and observation, interfused with values. Understanding historical and philosophical perspectives, students may come to know enough to account for the intersubjectivity of scientific observation. They may come to know how to uncover values and biases in science and, perhaps, how to acknowledge relatedness, make room for reverence, and act in ways that restore and sustain Earth.

- Enlarge students' ways of knowing by bringing humanities into science and science into humanities.

Restricting the range of scientific or humanistic understanding or expression to a band of predetermined cognitive and pedagogical ways of knowing asks students to leave part of who they are outside the door. Let the boundaries blur. Fun, humor, beauty, drama, joy, love, and passion are part of science. Wrapped up in what it means to be human are scientific understandings of the Earth, our habitat. Integrating aspects of the

humanities into science and science into humanities can enlarge students' ways of seeing and knowing. A way of knowing, is "always and inevitably personal," said Gregory Bateson (1979), "The point of the probe is always in the heart of the explorer" (pp. 87-88). Intersubjectivity is present in perception, and in science a silent, ongoing conversation persists between the observer and the observed. Sensing patterns in nature, visual or rhythmic, is at the core of scientific understanding, according to Bateson. By becoming conscious of patterns that connect all living entities, students may come to know the interrelationships between consciousness, aesthetics, and the sacred. They may also come to know their own "spontaneous capacity to generate pattern and organization from within" (Wheatley, 1996, p. 21).

Learning at the interface of science and the humanities can be powerful. Science knows the power of the ecotone, that transition between two or more diverse communities, as for example, between forest and grassland. At that ecotone, is the tendency for increased variety and density; a rich ebb and flow of pulse and movement persists across the boundaries. The entangling edge of science and poetry is similar. Said nature poet A.R. Ammons (1965),

> run my poem through
> your life & it will
> exist in you
> like a protein
> molecule (p. 64).

Recommendations for Further Research

Research that seeks to determine the values and world views implicit in the essential academic learnings or science education standards of current education reform would be useful at this time. Once explicit, those values and views could be affirmed or augmented by consciously chosen values that are foundation to an essential ethic for teaching science in the new millennium.

Additional research into the science practiced by Native Americans and other indigenous cultures could help "bring us to our senses," build a sustainable science, and plan for the future of seven generations and beyond. How may indigenous peoples become a resource in the field of science and science education to help us understand, for example, Bell's theorem of connectedness with our hearts and bodies as well as our minds? How may we teach traditional nature-centered ways of knowing compatible with modern science that might bring balance to individuals and build sustainable communities? What can we learn from indigenous cultures about understanding at a deep level the unity suggested by quantum wholeness? What are the protocols used by Native Americans to expand their ways of knowing that might have implications for ecological transformation and for science education? Understandings gained from such research may open up the possibility of forming a culture that views the natural world as a sacred manifestation and science as an integration of the human heart and mind.

Toward An Essential Ethic

If an essential ethic for teaching science is to be effected in the new millennium, we must begin now. The importance of Earth-care values cannot be overstated. In the words of E. O. Wilson (1995),

> Humanity is part of nature . . . the more closely we identify ourselves with the rest of life, the more quickly we will be able to discover the sources of human sensibility and acquire knowledge on which an enduring ethic, a sense of preferred direction, can be built (Wilson, Notes from U.S. Senate Hearing Statement).

Replacing misperceptions about the nature of nature, the value of nature and the human relationship with nature is hard work and takes time. That work must be done in little time. "No important change in ethics was ever accomplished without an internal change in our intellectual emphasis, loyalties, affections, and convictions," (Leopold, 1949, pp. 209-210). To develop the leaders we need, an essential ethic must so suffuse science education that internal change occurs. This internal change will be finally and truly a displacement of misperceptions, a change in our way of seeing, and a re-imagining of the Earth. "We can be ethical only in relation to something we can see, feel, understand, love, or otherwise have faith in" (Leopold, 1949, p. 214).

Seeing, feeling, understanding, loving, and having faith in the whole of the natural world, including its spiritual dimensions, is the gift teachers may give their students in the new millennium.

Final Thoughts

William Wordsworth provides the final thoughts:

For I have learned
To look on nature, not as in the hour
Of thoughtless youth; but hearing oftentimes
The still, sad music of humanity,
Nor harsh nor grating, though of ample power
To chasten and subdue. And I have felt
A presence that disturbs me with the joy
Of elevated thoughts; a sense sublime
Of something far more deeply interfused,
Whose dwelling is the light of setting suns,
And the round ocean and the living air,
And the blue sky, and in the mind of man:
A motion and a spirit, that impels
All thinking things, all objects of all thought,
And rolls through all things. Therefore am I still
A lover of the meadows and the woods,
And mountains; and of all that we behold
From this green earth; of all the mighty world
Of eye, and ear--both what they half create,
And what perceive; well pleased to recognise
In nature and the language of the sense
The anchor of my purest thoughts, the nurse,
The guide, the guardian of my heart, and soul
Of all my moral being.

William Wordsworth
From "Lines Composed A Few Miles Above Tintern Abbey"
July 13, 1798

APPENDIX A

Questionnaire

Questionnaire: Part 1

Toward an Essential Ethic for Teaching Science in the New Millennium

How important do you believe the following qualities or values are to the work of a scientist and, therefore, to the science education of young people? For each of the qualities listed in the left-hand column, please indicate in the space provided the number of your response. Use the scale below. (Please note: I am not asking you to rank order the qualities/values.)

3. Essential - must be included
2. Important - should be included
1. Somewhat important - would be nice, but not necessary
0. Not at all important - no need to be included

In the right-hand column, please provide a comment or justification to support your conclusion, or a brief example, possibly from your own experience.

No.	Quality/Value	Comment/Example
____	**Curiosity**: zest for knowing the truth of how the universe operates and of what the natural world is made; excitement in learning something new.	
____	**Wonder**: appreciation for, even delight in, the beauty, diversity, and complexity of nature; the joy of discovery.	
____	**Respect**: a sense of the intrinsic value of the natural world in all its variety and forms, human and nonhuman, aside from its utility and despite its wildness and mystery.	

3. Essential - must be included
2. Important - should be included
1. Somewhat important - would be nice, but not necessary
0. Not at all important - no need to be included

No.	Quality/Value	Comment/Example
____	**Reverence**: awe or adoration for the natural world that transcends respect for biogeochemical interconnections and acknowledges deep spiritual connection.	
____	**Receptivity**: openness in listening and responding, allowing answers to emerge, to reveal themselves in research; patience with the process.	
____	**Humility**: study of the natural world that acknowledges human limitations; does not make assumptions based on partial knowledge.	
____	**Love**: study and research motivated by a strong, positive attitude toward the natural world; a passion for the work; a feeling for the organism.	

3. Essential - must be included
2. Important - should be included
1. Somewhat important - would be nice, but not necessary
0. Not at all important - no need to be included

No.	Quality/Value	Comment/Example
____	**Relatedness**: awareness of intimate, personal involvement with the subjects/objects of research; a feeling of kinship, attachment, or rapport with what is being studied.	
____	**Interdependence**: knowledge of the interconnectedness of organisms and their environments; a sense of the web of life, the ecological balance of nature.	
____	**Unity**: holistic view of nature; a sense of the oneness, wholeness, and harmony of the natural world, including humans; not limited by dual or compartmental thinking.	
____	**Care**: close attentiveness to the subjects/objects of study and pleasure in getting to know them; concern for well-being and flourishing of all life; patience, not driven for immediate results.	

3. Essential - must be included
2. Important - should be included
1. Somewhat important - would be nice, but not necessary
0. Not at all important - no need to be included

No.	Quality/Value	Comment/Example
____	**Cooperation**: attitude and behaviors of collaboration, flexibility, and sharing; sees harmony as a fundamental force in survival and adaptation of nature and among peoples.	
____	**Responsibility**: concern about the likely consequences of research; long-term approach; consideration of future generations; commitment to make the world a better place.	
____	**Imagination**: conceptual powers of imagery, even fantasy, to help envision, create, predict, and guide research progress and possibilities.	
____	**Intuition**: ability to sense and follow hunches or leads that seem promising, that resonate with available information; trust that a relaxed, playful mind fosters new insights and creative leaps.	

Questionnaire: Part 2

Toward an Essential Ethic for Teaching Science in the New Millennium

Hundreds of individuals--scientists and poets alike--have written about their own direct and sometimes profound relationship with nature. Following are excerpts from the writings of individuals describing their experiences. Please read these excerpts before proceeding to the next question.

"On the way home I turned my attention to looking at Earth and the cosmos. Unexpectedly I experience an exhilarating sense that I and the universe were one--that it is but an extension of myself, that each of us is an integral part of the same existence. That was a very heady experience for me--exciting, joyous, and perplexing." (Edgar Mitchell, Apollo Astronaut)

"The sun shines not on us but in us. The rivers flow not past, but through us.... The trees wave and the flowers bloom, in our bodies as well as our souls, and every bird song, wind song, and tremendous storm song of the rocks in the heart of the mountains is our song, our very own, and sings our love." (John Muir, Nature Writer)

"I love the land. I think that if we are at all honest in those private moments, that is what we feel. It is in our DNA." (Terry Tempest Williams, Poet, Naturalist)

"The earth's vegetation is part of a web of life in which there are intimate and essential relations between plants and the earth, between plants and other plants, between plants and animals. Sometimes we have no choice but to disturb these relationships, but we should do so thoughtfully, with full awareness that what we do may have consequences remote in time and place." (Rachel Carson, Ecologist)

"In Wildness is the preservation of the world. The most alive is the wildest.... When I would recreate myself, I seek the darkest wood, the thickest and most interminable, and, to the citizen, most dismal swamp. I enter a swamp as a sacred place, -- a sanctum sanctorum. There is the strength, the marrow of Nature." (Henry David Thoreau, Naturalist)

"I found that the more I worked with [chromosomes under the microscope] the bigger and bigger they got, and when I was really working with them I wasn't outside, I was down there. I was part of the system.... It surprised me because I actually felt as if I were right down there and these were my friends." (Barbara McClintock, Nobel Laureate)

"Humankind has not woven the web of life. We are but one thread within it. Whatever we do to the web, we do to ourselves." (Attributed to Chief Seattle)

"Everything that is in the heavens, on the earth, and under the earth, is penetrated with connectedness, penetrated with relatedness." (Hildegard of Bingen, 12th Century Scientist)

"A leaf, a drop, a crystal, a moment of time is related to the whole, and partakes of the perfection of the whole. Each particle is a microcosm, and faithfully renders the likeness of the world.... A rule of one art, or a law of one organization, holds true throughout nature." (Ralph Waldo Emerson, Nature Writer)

"The state of feeling which makes one capable of such achievement is akin to that of the religious worshiper or of one who is in love." (Albert Einstein, Scientist)

A. What has been your direct experience with nature? At any time or place in your life, or while in laboratory or field work, have you ever had a direct experience in nature, or working with the constituents of nature, that you would describe as transcendent, relational, or spiritual, or an experience that brought you to a sense of oneness with nature or to profound ethical or moral concern or insight, strong attachment, passion, joy, or love? If so, please briefly describe that experience, tell when in your life and where it occurred, and answer the questions that follow. You may use the back of the page or additional sheets if necessary.

B. How was this experience important to your understanding of the natural world? Please describe.

C. How was this experience important to your development as a scientist? Please describe.

Your name_____ Years as a scientist _____

Position/Organization_____

Address _____ Phone_____

_____ e-mail_____

What is your primary science discipline?_____

Optional: ___Male ___Female Racial/ethnic origin _____

APPENDIX B

Form for Results of Round-One Questionnaire

Results of Round-One Questionnaire: Part I

Toward an Essential Ethic for Teaching Science in the New Millennium

The table below shows your ratings of the values/qualities that may (or may not) be important to you as a scientist. The percentages shown are summaries of all responses to the questionnaire. Your individual rating is also shown.

Please ask yourself once again, "What values/qualities are essential or important to you in your work as a scientist?" Then please confirm or change your rating. Attached are comments made by you and your peers about each of the values/qualities. They may help you decide how to respond.

3. Essential - must be included
2. Important - should be included
1. Somewhat important - would be nice, but not necessary
0. Not at all important - no need to be included

Quality/Value	3 %	2 %	1 %	0 %	Your previous rating is below	I agree with my previous rating	I change my previous rating. Circle below
Curiosity						__yes __no	3 2 1 0
Wonder						__yes __no	3 2 1 0
Respect						__yes __no	3 2 1 0
Reverence						__yes __no	3 2 1 0
Receptivity						__yes __no	3 2 1 0
Humility						__yes __no	3 2 1 0
Love						__yes __no	3 2 1 0
Relatedness						__yes __no	3 2 1 0
Interdependence						__yes __no	3 2 1 0
Unity						__yes __no	3 2 1 0
Care						__yes __no	3 2 1 0
Cooperation						__yes __no	3 2 1 0
Responsibility						__yes __no	3 2 1 0
Imagination						__yes __no	3 2 1 0
Intuition						__yes __no	3 2 1 0

APPENDIX C

Nature Writers: Values

Nature Writers: Values

Curiosity: zest for knowing the truth of how the universe operates and of what the natural world is made; excitement in learning something new.

Wonder: appreciation for, even delight in, the beauty, diversity, and complexity of nature; the joy of discovery.

Respect: a sense of the intrinsic value of the natural world in all its variety and forms, human and nonhuman, aside from its utility and despite its wildness and mystery.

Reverence: awe or adoration of the natural world that transcends respect for biogeochemical interconnections and acknowledges deep spiritual connection.

Receptivity: openness in listening and responding, allowing answers to emerge, to reveal themselves in nature, patience with the process.

Humility: study of the natural world that acknowledges human limitations; does not draw conclusions based on partial knowledge.

Love: intense attraction or devotion to the natural world;, a passion for nature; a feeling for the organism.

Relatedness: awareness of intimate, personal involvement with the natural world; a feeling of kinship, attachment, or rapport with the constituents of nature.

Interdependence: knowledge of the interconnectedness of organisms and their environments; a sense of the web of life, the ecological balance of nature.

Unity: holistic view of nature; a sense of the oneness, wholeness, and harmony of the natural world, including humans; not limited by dual or compartmental thinking.

Care: concern for well-being and flourishing of all beings; close attentiveness to the things of nature; pleasure and patience in getting to know them.

Cooperation: attitude and behaviors of collaboration, flexibility, and sharing; sees harmony as a fundamental force in survival and adaptation of nature.

Responsibility: concern about the likely consequences of behaviors that affect the natural world; consideration of future generations; commitment to make the world a better place.

Imagination: conceptual powers of imagery, even fantasy, to help envision, create, predict, and guide behaviors, progress, and possibilities.

Intuition: ability to sense and follow hunches or leads that seem promising, that resonate with available information; trust that a relaxed, playful mind fosters new insights.

APPENDIX D

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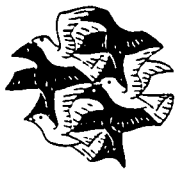

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